Report

The Status and Quality of Year 11 and 12 Science in Australian Schools

Prepared for the Office of the Chief Scientist

Denis Goodrum

Amelia Druhan

Joanna Abbs

Australian Academy of Science

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Australian Government

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GPO Box 783
Canberra ACT 2601
Telephone: 02 6201 9400
Fax: 02 6201 9400

Executive Summary

This study was commissioned by the Office of the Chief Scientist and funded by the Australian Government Department of Innovation, Industry, Science, Research and Tertiary Education.

The research team comprised Professor Denis Goodrum, Amelia Druhan and Joanna Abbs of the Australian Academy of Science.

Research Design

The purpose of the study was to develop a clear understanding of Year 11 and 12 science in Australian schools and the potential issues involved. The research approach develops two pictures. The first picture captures the best of what we want for our science students; the ideal. This ideal picture should embrace our high but realistic aspirations for Year 11 and 12 students. The other picture is a clear appraisal of what is actually happening in Year 11 and 12 science classrooms at the present time throughout Australia. With the two pictures clearly described on the available data the study then provides an analysis of the issues by which we pragmatically move from the present actual to the attainable ideal.

Methods and Data Sources

The study employs a mixed-method design that measures overlapping but different aspects by which richer descriptions of the ideal and actual pictures are developed. Data sources include:

- a systematic review and analysis of state, national and international reports, science education literature and curriculum documents
- student survey of Year 11 and 12 science and non-science students in New South Wales, South Australian and the Australian Capital Territory in schools chosen by a stratified random sampling procedure
- telephone survey of senior science teachers in New South Wales, South Australia and the Australian Capital Territory in schools also chosen by a stratified random sampling process
- focus group meetings with students, teachers, scientists and community members.

Ideal Picture

The ideal picture is described in a number of themes. These themes are grouped around the four focus areas of students, teachers, resources and values.

Students and their Curriculum

Theme 1: The science curriculum is relevant to the needs, concerns and personal experiences of the students.

Theme 2: The teaching and learning of science is centred on inquiry. Students investigate, construct and test ideas and explanations about the natural world.

Theme 3: Assessment serves the purpose of learning and is consistent with and complimentary to good teaching.

Teachers and their Profession

Theme 4: The teaching-learning environment is characterised by enjoyment, fulfilment, ownership and engagement in learning and natural respect between teacher and students.

Theme 5: Teachers are professionals who are supported so that they can reflect and build the understanding and competencies required of best practice.

Theme 6: Teachers of science including Year 11 and 12 have a recognised career path based on sound professional standards endorsed by the profession.

Resources for Teaching and Learning Science

Theme 7: Excellent facilities, equipment and resources support teaching and learning.

Theme 8: Sufficient time is available by which teachers can prepare, teach and assess student science learning.

The Value of Science Education

Theme 9: Science and science education are valued by the community, have high priority in the school curriculum and science teaching is perceived as exciting and valuable, contributing significantly to the development of persons and to the economic and social well-being of the nation.

Actual Picture

The actual picture is painted by focusing on different dimensions of the school experience: the students, the curriculum, the pedagogy, the teachers and finally the resources.

The Students

One of the surprising results is the dramatic fall in the collective number of students studying science. In the early nineties, nine out of ten students in Year 12 studied science. Today, that figure has shrunk to half the Year 12 cohort. The general picture that emerges is that fewer students are studying science but these fewer students enjoy the science they experience and it is in keeping with their expectations for the future. Science students have a very positive view about science and its importance in broader society.

The Science Curriculum

The view of teachers and students as derived from the surveys and focus groups is that Year 11 and 12 science is constructed to prepare students for university study. This university preparation perspective has resulted in an overcrowded content-laden curriculum. With the amount of content to be covered there is little room for flexibility from either the teacher or student. The science courses are perceived to be conceptually difficult with an emphasis on theoretical abstract ideas.

Science Teaching and Learning

The content-laden curriculum encourages science in Year 11 and 12 to be taught in a traditional way using the transmission model. This approach is revealed by the fact that 73% of science students indicated that they spend every lesson copying notes from the teacher while 65% never or seldom have choice in pursuing areas of interest. Teacher demonstrations are common, with 79% of science students suggesting this occurs often, very often or always in a lesson. The practical work tends to be 'recipe based' with students required to follow specific instructions to achieve known results. In some states there are assessable open-ended student investigations. From the focus group discussion with teachers there was a concern about these investigations. The investigations were placing significant demands on both students and teachers.

Year 11 and 12 Science Teachers
Science in Year 11 and 12 is taught by the most qualified and most experienced science teachers. In the telephone survey, three quarters of the interviewed teachers indicated they had a Bachelor of Science. Only 7% had no science qualifications.

Resources
The heavy content curriculum puts significant pressure on teachers as they attempt to help their students. The most common factors that teachers listed as limiting their teaching were time (36%) and resources (23%).

Recommendations

Recommendation 1
The Australian Curriculum: Science courses of Biology, Chemistry, Earth and Environmental Science and Physics need to include a realistic amount of content for the time available. Furthermore, all the three strands of Science Understanding, Science as a Human Endeavour and Science Inquiry Skills need to be adequately covered in the content.

Recommendation 2
Attention needs to be directed to recapturing the interest of students in Years 7 to 10 science by supporting a program like Science by Doing.

Recommendation 3
A set of guidelines be developed to provide quality advice to Year 10 students considering selecting Year 11 and 12 science subjects.

Recommendation 4
Provide more professional learning opportunities for senior science teachers to expand their teaching skills including the latest scientific developments.

Recommendation 5
Develop a suite of digital curriculum resources for the new national curriculum subjects that will assist teachers.

Recommendation 6
Increase the number of paraprofessionals, especially laboratory technicians, to support teachers.

Recommendation 7
Relevant boards of study need to evaluate the value, impact and implementation of large scale student investigation assessment activities.

Recommendation 8
Re-examine the various pathways by which people may train (or retrain) to become teachers. The intention should be to increase options by removing barriers while maintaining quality. In particular,

employing authorities should be encouraged to acknowledge the relevant skills and knowledge that new teachers bring with them from previous work experience in determining salaries (Goodrum and Rennie, 2007, p24).

In Conclusion

While the report clearly identifies the impact of an overcrowded and abstract curriculum in Year 11 and 12 science courses, it also challenges us to consider what is the purpose of science learning during these senior years of secondary education. There is a strong prevailing view that the senior science subjects, especially biology, chemistry and physics, are preparation for university. Furthermore, the reason for studying these subjects, that some consider elitist, is to maximise a student's final university entrance score. This score provides the basis for course and university selection.

The report asks the following question: 'Are we as a nation content that only half our senior secondary students are studying science?' If we are, then the years F to 10 and especially the compulsory high school years become critical in developing the scientific literacy of our students.

The lower secondary years 7 to 10 are also important in terms of generating interest in science. The decrease in the number of students studying senior science is a reflection of our failure to engage students in science in lower secondary. For this reason a program like *Science by Doing* becomes very important in addressing this issue.

For a country that believes its future prosperity is based on innovation and a skilled workforce this question needs to be addressed.

If one assumes that change needs to occur then how can this be done? The research outlined in this study clearly shows teachers are the key to educational improvement. While new teachers entering the system will assist, the real momentum for change will come from those experienced teachers already in the system. For this reason an extensive professional learning effort is required to help teachers work together with relevant quality resources to bring about the change that is needed.

To bring about this change there is a need for political leadership and financial support. With this leadership and funding, positive change will occur.

Acknowledgements

In collecting data for this study the research team relied on the goodwill and cooperation of many people. In particular, the team would like to thank

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    - Ingrid Bean, ACT
    - Lyn Jefferies, SA
    - Peter van der Zwagg, SA
    - Jane West, NSW
- the many students, teachers, scientists and community members for their insights into the teaching and learning of Year 11 and 12 science.

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1. Introduction

> "*Over the next ten years, nearly half of all jobs will require education beyond high school, many requiring proficiency in math and science. … If we want to win the global competition for new jobs and industries we've got to win the global competition to educate our people*." (Obama, 2011)

While these words by President Barack Obama related to the United States of America, they are equally true for Australia. In reflecting on these ideas it is appropriate to focus our attention on the senior years of secondary school.

The purpose of the study outlined in this report is to develop a clear understanding of Year 11 and 12 science in Australian schools and the potential issues involved.

The research approach attempts to develop two pictures. The first picture captures the best of what we want for our science students; the ideal. This ideal picture should embrace our high but realistic aspirations for Year 11 and 12 students.

The other picture is a clear appraisal of what is actually happening in Year 11 and 12 science classrooms at the present time throughout Australia.

There is an assumption that these two pictures are not the same. This study provides a basis for determining just how different the actual is from the ideal. With the two pictures clearly described on the available data the study then provides an analysis of the issues by which we pragmatically move from the present actual to the attainable ideal.

1.1. Research Questions

1. What are our expectations for Year 11 and 12 school science? – The ideal picture.
2. What is happening in Year 11 and 12 science classrooms? – The actual picture.
3. How do we move from the present actual picture to one that is in keeping with our expectations?

1.2. Research Design

The research design framework (summarised in Figure 1.1) shows the various data sources that have been used to construct the two pictures of the ideal and the actual situation for Year 11 and 12 science.

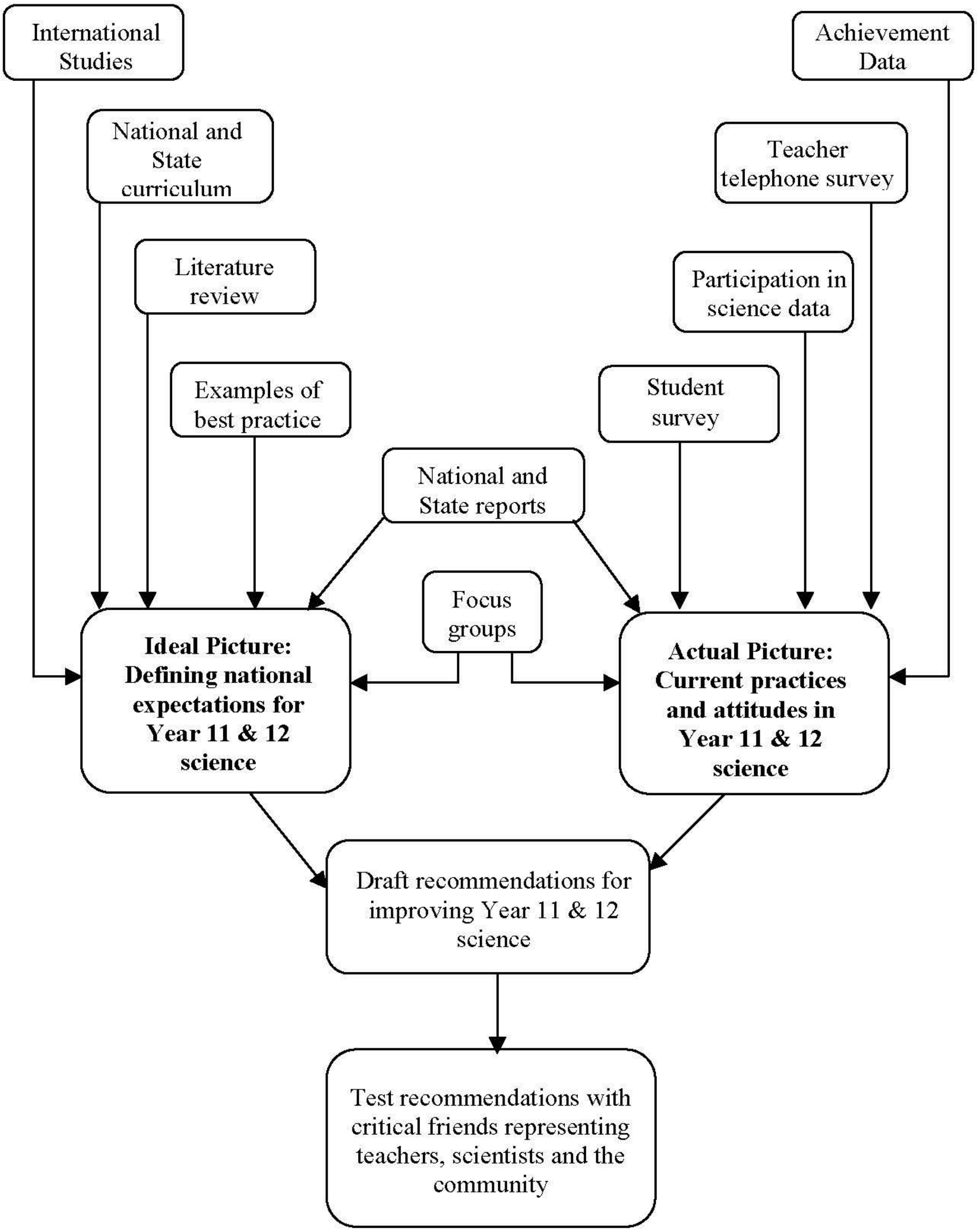

Figure 1.1: Research Design Framework

The ideal picture of our expectations is developed from the following data sources.

Literature review: The science education and the general education literature from national and international sources have been reviewed to identify factors that influence and contribute to senior secondary science.

National and state curriculum documents: Curriculum documents from the states and the Australian Curriculum, Assessment and Reporting Authority (ACARA) have been analysed to identify learning expectations and science subjects for Year 11 and 12.

International studies: Selected international studies and curriculum documents have been examined.

Examples of best practice: Some states have created high schools that have a science focus. One of these schools has been examined.

In contrast to the ideal picture, the actual picture has been constructed from the following data sources.

Student survey: Views have been gathered from science and non-science Year 11 and 12 students by a questionnaire. The questionnaire seeks information on attitudes to science, school science and career aspirations. The survey has been circulated to randomly selected schools in New South Wales, South Australia and the Australian Capital Territory.

Teacher telephone survey: A randomly selected sample of Year 11 and 12 science teachers from New South Wales, South Australia and the Australian Capital Territory have been surveyed by telephone to obtain their views about science teaching and learning.

Participation in science data: Using a variety of sources, data has been obtained about the enrolment of students in science generally and science subjects over the past two decades.

Achievement data: The science achievement of high school students has been examined using such sources as the Trends in International Mathematics and Science Study (TIMSS) and the Programme for International Student Assessment (PISA).

Both the ideal and the actual pictures of science teaching and learning have also been enhanced by the following two sources of data.

Focus groups: A variety of focus groups have been conducted to provide a richer description of ideas and issues about Year 11 and 12 school science. Separate focus groups have been conducted with Year 11 and 12 students, teachers and a community group involving scientists, parents and peak science associations.

National and state reports: A range of recent national and state reports have been examined to provide additional insights in to Year 11 and 12 school science.

In conducting this study three national reports in particular have been very influential. A decade ago an extensive and detailed investigation of Australian school science was undertaken (Goodrum, Hackling and Rennie, 2001). This report and its approach form the foundation of this study with its focus on Year 11 and 12. The second report, presented in two volumes, was the Australian School Science Education Action Plan, 2008-2012 (Goodrum & Rennie, 2007). This report builds on the 2001 report. The final report of significance is the Australian Council of Education Research (ACER) monograph on Participation in Science, Mathematics and Technology in Australian Education (Ainley *et al*, 2008). The statistical information is particularly illuminating.

2. Review of Literature and Reports

2.1. Introduction

The Shape of the Australian Curriculum: Science (ACARA, 2009) was prepared to guide the development of science curriculum for Foundation to Year 12. The document outlines the aims of the science curriculum, in particular to

> "*Foster an interest and a curiosity and willingness to speculate about and explore the world. Students should be able to engage in communication of and about science, value evidence and scepticism, and question scientific claims made by others. They should be able to identify and investigate scientific questions, draw evidence-based conclusions and make informed decisions about their own health and wellbeing. Science is a human endeavour that students should learn to appreciate and apply in their daily life*." (ACARA, 2009, p5)

These words embody the essence of scientific literacy. That is, the importance of all citizens understanding science and being able to apply the tenets of science to their own life.

It is also acknowledged that the science curriculum needs to meet the needs of students who will become scientists and engineers or be involved in science related professions.

Fensham (1985) suggested that in previous years these two demands on science education, that is, scientific literacy and preparation of scientists, cause conflict and tension within the school science. Fensham indicated that senior science courses were designed to select and prepare students for further university science study. As a result, they have a heavy discipline-based focus involving large amounts of content and abstract principles with limited attention to any social significance. These tensions are present in other countries as well as Australia (Bybee, 1997; Millar & Osbourne, 1998; Goodrum & Rennie, 2007).

2.2. Nature of Year 11 and 12 Science

The tension between an emphasis on scientific literacy and the preparation of students for university science is an important issue in Year 11 and 12 science. Contained within this is an acknowledgement that there are some differences between Year 11 and 12 science and the other years of school science.

The most important difference is that learning science is not mandated for Year 11 and 12. For Foundation to Year 10 the Australian Curriculum: Science is compulsory for all students (ACARA, 2011). Furthermore, the curriculum is explicit in its learning content for all years from Foundation to Year 10.

In the preparation of the Shaping Paper (ACARA, 2009) a proposal for mandatory science for Year 11 and 12 was considered but later rejected. While science would be optional for Year 11 and 12 students the basic principles of the Shaping Paper would also apply to these years. Within these years the three Australian Curriculum: Science strands of Science Understanding, Science as a Human Endeavour and Science Inquiry Skills would be evident.

The nature of Year 11 and 12 science is influenced by the structure of the school. The most common structure within Australia is that Year 11 and 12 are taught in a secondary school that caters for

Years 7/8 to Year 12. Many science teachers of Year 11 and 12 also teach students from the lower secondary years. This is not the case in the Australian Capital Territory where there are separate Government schools for Year 7 to 10 and colleges for Years 11 and 12.

The other significant aspect of Year 11 and 12 is that for the majority of the jurisdictions there are external examinations at the end of Year 12 for many subjects. This is not the case for Queensland and the Australian Capital Territory where school-based assessment occurs with an across-school moderation process.

2.3. Teaching and Learning in Science

Many submissions and witnesses for the inquiry into the promotion of mathematics and science education by the education and training committee for Victorian Parliament (ETC, 2006) indicated there was an over-emphasis on the preparation of science specialists in Year 11 and 12 at the expense of developing scientific literacy for the broader range of students. Furthermore this focus on narrow discipline-based courses for science specialists impacted on the way the science courses were generally taught.

According to the Science Teachers Association of Victoria, teaching had become 'bogged down in memorising factual content' (ETC, 2006, p38).

While there is still much we do not know about how people learn, we have acquired a much better understanding in recent decades.

The prevailing view of learning in science is that learners construct their own knowledge and understandings based on what they already know and the context in which they find themselves. Learning is an active process in which learners try to make sense of their experiences by constructing meaningful understandings. Learners therefore develop knowledge and ideas in science by linking new information to their existing conceptual frameworks. Thus, learners' prior knowledge and understanding become crucial determinants of new knowledge and understanding.

The Shaping Paper for the Australian Curriculum: Science (ACARA, 2009) proposed that there should be less emphasis on the transmission model of pedagogy and more emphasis on a model of student engagement and inquiry.

> "*The driving force of the transmission model is teacher explanation whereas the learning engine for inquiry is based on teacher questions and discussion. Teacher explanation is still important but it should be seen as one skill in a broad repertoire of teaching skills.*
>
> *A balanced and engaging approach to teaching science will typically involve context, exploration, explanation and application. Wherever appropriate, students should be actively involved in the science concepts being taught. This requires a context or point of relevance by which students can make sense of the ideas to be learnt. The context may vary depending on the students, school or location. Having set the scene, the teacher provides science activities by which students can explore the ideas, using language the students are familiar with. Using this exploration and experience as a basis, the teacher introduces the science concepts and science terms in a way that has meaning to students. With these explanations and science language, the teacher then provides activities through which students can apply the science concepts to new situations*." (ACARA, 2009, p13)

There has been resistance to adopting a more inquiry-based approach to science teaching. A number of authors (Fensham, 1997; Goodrum *et al*, 2001; ETC, 2006) have suggested that the heavy, specialist science courses of senior secondary have filtered down to junior secondary science. The transmission model, so well-entrenched in the senior years, was maintained in the junior years for consistency and coherence. The resulting science in lower-secondary has generally lacked meaning and relevance to many students. Traditional chalk-and-talk teaching, copying notes and 'cookbook' practical lessons have offered little challenge or excitement to students (Goodrum *et al*, 2001). In recent years, however, there has been considerable effort made to change the pedagogy in junior-secondary science. Including the Australian Academy of Science's innovative *Science by Doing* program. Perhaps this more enlightened approach in the junior years should influence how science is taught in Years 11 and 12.

2.4. Science Courses in Year 11 and 12

The various science courses presently available in each state and territory are outlined in Table 2.1. While initially there seems to be quite a variation in reality there is considerable similarity. Each jurisdiction has a course or courses related to the three traditional disciplines of Biology, Chemistry and Physics.

With the implementation of the Australian Curriculum: Science the decision is that for Year 11 and 12 there will be four science courses common across Australia. These courses are Biology, Chemistry, Earth and Environmental Science and Physics. These curricula are presently being developed and will be available in 2012 for further consultation.

The expectation is that while these courses will be common across Australia, states and territories may wish to also provide other science courses beyond these four.

In examining the range of courses beyond the traditional disciplines a number of states have developed a general science course. Various titles include Senior Science, Science 21, Integrated Science and Scientific Studies. In the development of the Shaping Paper (ACARA, 2009) a course called Science for Life and Living was considered. This was a general science course with an emphasis on the application of science to everyday life. This course was not accepted because there was a belief it would be perceived as a second rate course. Unfortunately, this has been the common response among many teachers and students to the general science courses. It is for this reason the fourth science course after Biology, Physics and Chemistry was decided to be Environmental Science. After consultation and pressure from sections of the community this became Earth and Environmental Science.

Table 2.1: Science courses offered in each state or territory for Year 11 and 12

ACT	NSW	NT	QLD	SA	TAS	VIC	WA
Science courses							
Taught at all ACT colleges • Chemistry • Physics • Life Sciences **Other potential science courses** • Agriculture • Animal husbandry • Aquatic science • Astronomy • Biotechnology • Climatology • Cosmetics and hair care • Electronics • Electrotechnology • Environmental science • Forensic science • Forestry • Geology • Horticulture • Laboratory skills • Marine biology • Materials science • Meteorology • Mineralogy • Natural disasters • Oceanography • Physiology • Viticulture	• Biology • Chemistry • Earth and Environmental Science • Physics • Senior Science	Same as SA	• Agricultural Science • Biology • Chemistry • Earth Science • Marine Studies • Multi-Strand Science • Physics • Science21	• Agriculture and Horticulture • Biology • Chemistry • Geology • Nutrition • Physics • Psychology • Scientific Studies	• Life Science 2 • Biology 2 • Environmental Science 3 • Science of the Physical World 2 • Physical Sciences 3 • Chemistry 3 • Physics 3	• Biology • Chemistry • Environmental Science • Physics • Psychology	• Biological Sciences • Chemistry • Earth and Environmental Science • Human Biological Science • Integrated Science • Physics • Psychology

(Sources: State and territory education websites)

2.5.Participation in Year 11 and 12 Science

Since 1991 the Department of Education, Employment and Workplace Relations (or its equivalent) has collected and collated school enrolment information from the states and territories. Prior to that date a group of dedicated academics undertook the task for Year 12 mathematics and science subjects (Dekkers, De Laeter, J.R. and Malone, 1991). Using the approach taken by these academics, researchers for the Australian Council for Educational Research (Ainley *et al*, 2008) have provided the information for the period 1991 to 2007 in Table 2.2 and Figure 2.1. Since states and territories have used a variety of course names over the period these have been grouped together into equivalent subject labels. The traditional titles of Physics, Biology and Chemistry have been used. The term Other Sciences includes the variety of general science courses as well as the specialist courses such as marine studies and agriculture. The subject Psychology was introduced in 1990 in Victoria and was subsequently taken up by students. In subsequent years it has also been available in South Australia and Western Australia. There are some in the education system who question its classification as a science subject.

While the specific enrolment data for each subject for each year is useful, a better figure is the percentage of students enrolled in the subject for that year. Total student enrolment for each year varies considerably. This percentage figure provides a better basis for comparing one year to the next and observing trends.

Figure 2.1 shows that since 1991, the percentage of students enrolled in Biology, Chemistry and Physics has been gradually falling. For Biology the fall has been from 35.9% in 1991 to 24.7% in 2007, for Chemistry 23.3% in 1991 to 18.0% in 2007 and for Physics 20.9% in 1991 to 14.6% in 2007. While the fall has slowed there is no indication that it has stopped.

The subject of Psychology has risen from 4.9% in 1992 to a height of 9.2% in 2006 while Geology and the Other Sciences have remained at a reasonably constant percentage of 1% and 8% respectively with slight variations over the years.

Table 2.2: Year 12 Science participation

Science subject title	Year																
	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Numbers of students enrolled																	
Biology	65852	67833	63230	54872	51498	51032	49932	49677	50339	50675	47744	47770	48532	48774	48807	49245	48964
Chemistry	42645	43594	41372	36894	35711	35466	35821	34225	34259	35130	33554	33105	34074	35230	35734	35490	35697
Physics	38260	39690	36749	31890	30673	31128	31532	30490	30622	30805	31016	30552	31141	31588	29506	28730	28931
Psychology	1731	9462	11147	11257	11794	11922	12941	13001	13446	13828	14670	15037	15824	16386	16982	18124	16858
Geology/earth science	2350	2460	2078	1607	1257	1134	975	960	982	924	1888	1809	1865	1956	2070	1883	1684
Other sciences	14088	18292	19060	17176	16217	15976	15965	14973	14694	15240	14713	14650	14617	13823	13421	13532	16386
Percentage of Year 12 students																	
Biology	35.9	35.2	33.8	30.5	29.9	30.0	28.9	28.0	27.6	27.3	25.4	24.7	25.1	25.2	25.1	25.1	24.7
Chemistry	23.3	22.6	22.1	20.5	20.7	20.8	20.7	19.3	18.8	18.9	17.8	17.1	17.6	18.2	18.4	18.1	18.0
Physics	20.9	20.6	19.7	17.7	17.8	18.3	18.2	17.2	16.8	16.6	16.5	15.8	16.1	16.3	15.2	14.6	14.6
Psychology	0.9	4.9	6.0	6.3	6.8	7.0	7.5	7.3	7.4	7.4	7.8	7.8	8.2	8.5	8.7	9.2	8.5
Geology/earth science	1.3	1.3	1.1	0.9	0.7	0.7	0.6	0.5	0.5	0.5	1.0	0.9	1.0	1.0	1.1	1.0	0.8
Other sciences	7.7	9.5	10.2	9.5	9.4	9.4	9.2	8.4	8.1	8.2	7.8	7.6	7.5	7.2	6.9	6.9	8.3

(Source: Ainley *et al*, 2008, p15)

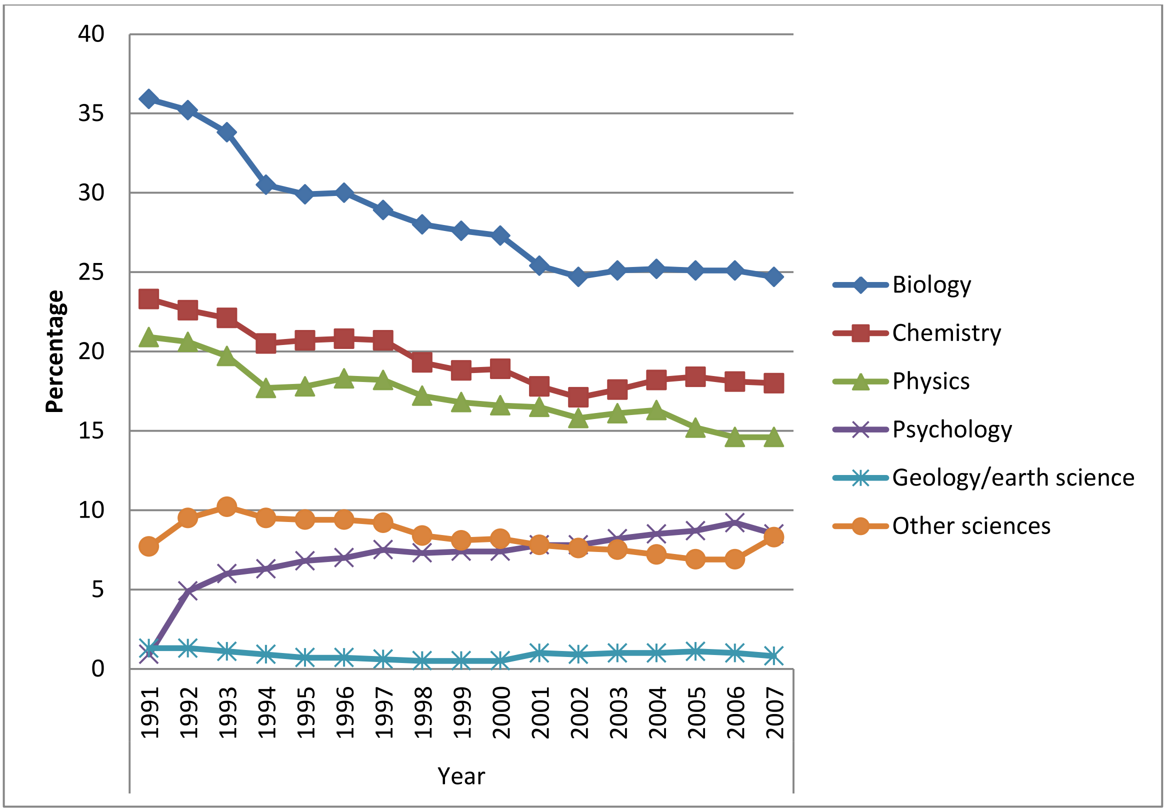

Figure 2.1: Year 12 science participation 1991-2007
(Source: Ainley et al, 2008, p18)

Students in Year 11 and 12 commonly study five or six subjects for the two year period. Since science is not compulsory beyond Year 10 students may study none, one, two or even three science subjects. Using information provided by the Department of Education Employment and Workplace Relations and the Australian Bureau of Statistics, Table 2.3 and Figure 2.2 were developed to examine the number studying science in Year 12 during the past two decades. The students may have studied one or more science subjects. The enrolment numbers have been converted into a percentage figure for each year to provide a better way of comparing years and determining trends.

These data show that there has been a dramatic fall in the percentage of students studying science in Year 12 from a height of 94.1% in 1992 to a low of 51.42% in 2010. In examining the data one observes that from 2001 to 2002 there was a particularly large decrease in enrolments. The fall was occurred in all states and territories. Since states and territories determine their policies independently there does not appear to be a specific policy change that would account for this change. At the point of writing no explanation has been uncovered.

It should be noted that the graph indicates a continued downward trend. While the decrease is slowing there is no indication that enrolments have reached the lowest point.

Year	Students studying science in Year 12	Total students in Year 12	% of students studying science in Year 12
1991	164,926	183,432	89.91%
1992	181,331	192,707	94.10%
1993	173,636	187,071	92.82%
1994	153,696	179,908	85.43%
1995	147,150	172,234	85.44%
1996	146,658	170,729	85.90%
1997	147,166	172,772	85.18%
1998	143,326	177,234	80.87%
1999	144,342	182,498	79.09%
2000	146,602	185,810	78.90%
2001	143,585	188,110	76.33%
2002	105,761	193,672	54.61%
2003	108,141	193,616	55.85%
2004	116,617	193,482	60.27%
2005	106,922	194,165	55.07%
2006	106,301	196,582	54.07%
2007	105,599	198,216	53.27%
2008	106,591	202,577	52.62%
2009	107,630	206,526	52.11%
2010	110,328	214,542	51.42%

Table 2.3: Student participation in science 1991-2010
(Source: Data from DEEWR and ABS)

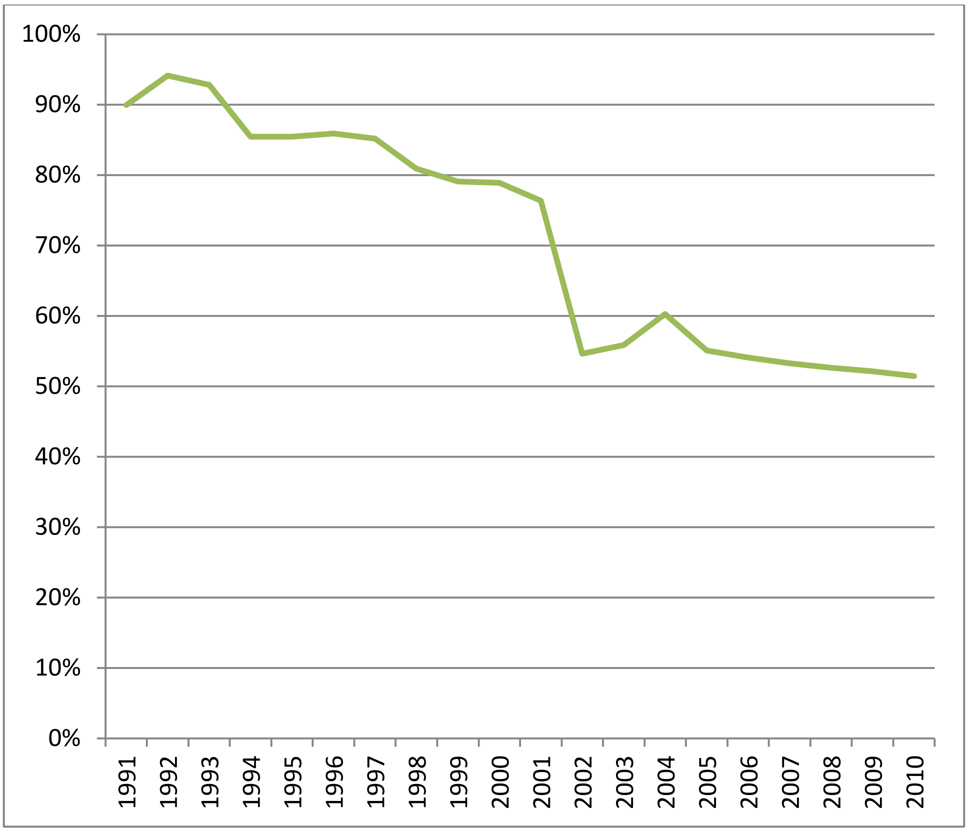

Figure 2.2: Student participation in science 1991-2010
(Source: Data from DEEWR and ABS)

2.6.Student Achievement in Science

To obtain an appreciation of student science achievement, especially in comparison to other countries, there are two international ongoing programs that have been assessing science learning for a number of years. They are the Programme for International Student Achievement (PISA), derived from the Organisation for Economic Cooperation and Development (OECD), and the Trends in International Mathematics and Science Study (TIMSS), conducted by the International Association for the Evaluation of Educational Achievement (IEA). PISA assesses the reading, mathematical and scientific literacy skills of 15-year-old school students (mainly Year 10) and TIMSS provides information about the mathematical and science performance of Year 4 and Year 8 students.

PISA has examined the level of scientific literacy every three years for the past decade with an extensive examination in 2006. Table 2.4 provides a comparison of results for countries involved in the 2009 study. Australia was above the average of 501 with a result of 527. Within this range there were seven other countries with results not significantly different to Australia. These countries included New Zealand, Canada, Germany and the Netherlands. There were six countries significantly higher than Australia. These better performing countries were Shanghai-China, Finland, Hong Kong, Singapore, Japan and Korea. There were 36 countries that performed lower than Australia.

Country/economy	Mean score	
Shanghai–China	575	Significantly higher than Australia
Finland	554	
Hong Kong–China	549	
Singapore	542	
Japan	539	
Korea	538	
New Zealand	532	Not significantly different to Australia
Canada	529	
Estonia	528	
Australia	**527**	
Netherlands	522	
Chinese Taipei	520	
Germany	520	
Liechtenstein	520	
Switzerland	517	Significantly lower than Australia
United Kingdom	514	
Slovenia	512	
Macao–China	511	
Poland	508	
Ireland	508	
Belgium	507	
Hungary	503	
United States	502	
OECD average	**501**	
Czech Republic	500	
Norway	500	
Denmark	499	
France	498	
Iceland	496	
Sweden	495	
Austria	494	
Latvia	494	
Portugal	493	
Lithuania	491	
Slovak Republic	490	
Italy	489	
Spain	488	
Croatia	486	
Luxembourg	484	
Russian Federation	478	
Greece	470	
Dubai (UAE)	466	
Israel	455	
Turkey	454	
Chile	447	
Serbia	443	
Bulgaria	439	
Romania	428	
Uruguay	427	
Thailand	425	
Mexico	416	

Table 2.4: PISA Results – 2009

In examining the results of the PISA study over the decade for Australia, an interesting trend appears to be developing. Table 2.5 outlines the number of countries that performed significantly better than the strand of countries with which Australia was aligned. In 2000 two countries, Korea and Japan, performed better than Australia, but in 2003 and 2006 three countries outperformed Australia. In 2009 this number had risen to six countries as previously outlined. Australia's performance in scientific literacy remained unchanged from 2006 to 2009 while some other countries improved their performance.

2000	2003	2006	2009
Korea Japan	Finland Japan Korea	Finland HK Canada	China Finland HK Singapore Japan Korea
Australia	Australia	Australia	Australia

Table 2.5: Countries that outperform Australia in PISA testing

During the past decade, TIMSS undertook student assessments in 2003 and 2007, With an international average of 500, Australia obtained a score of 515 on the Year 8 study in 2007 that was 12 score points lower than the 2003 study. The ACER report into the TIMSS 2007 study (Thomson and Buckley, 2007) observed that while Australia and the United States achieved at similar levels in 2003, in 2007 the United States outperformed Australia in almost all of the assessments items ACER reviewed.

The findings from both PISA and TIMSS indicate that Australia's science achievement is above international average. The disturbing trend is that while some other countries are improving their science achievement scores, as in the case of PISA, Australia's scores remain static and in the case of TIMSS the results for Year 8 have actually fallen.

2.7. Teachers of Science

Numerous reports (Goodrum *et al* 2001; Dow, 2003) recognise the self-evident fact that the quality of teachers affects the quality of student learning. While the supply and demand data for science teachers is difficult to obtain, there is sufficient indication (Dow, 2003) that the active recruitment of science teachers needs to be a priority, especially in the areas of physics and chemistry.

Most of the information about science teachers tends to be collected by surveys (Goodrum *et al*, 2001; Harris *et al*, 2005; McKenzie *et al*, 2008). The ACER survey of teachers suggests that Year 11 and 12 science teachers are well qualified and well experienced (McKenzie *et al* 2008). At least 70% of Year 11 and 12 chemistry teachers have three years or more of chemistry tertiary education, received training in the teaching of chemistry and have been teaching for more than five years. Less than 6% of chemistry teachers have no chemistry education. For Year 11 and 12 physics the figures are slightly less but still similar. Approximately 60% of physics teachers have at least three years of university physics study but again less than 6% have no university physics education.

So while there is a significant demand for physics and chemistry teachers those that teach in Year 11 and 12 are still qualified and experienced. The majority of science teachers in high school have university studies in the biological sciences.

3. Research Approach

The data used to describe the actual picture of science education (and to a lesser extent the ideal picture) in Australian schools have been gathered through focus groups of teachers, students, science education specialists and community members; a teacher telephone survey; and a student survey by questionnaire. Some information on an example of best practice has been included to inform the ideal picture. This section will describe each of these data sources and how the data were gathered.

3.1.Focus Groups

The purpose of the focus groups was to validate and inquire into key themes and trends apparent in the telephone interview and survey data. Three different types of focus groups were established and included groups of:

- Year 11 and 12 students
- Secondary science teachers
- Science education specialists and community members.

The number of participants in each group ranged from 10-19 and discussions lasted for 30-60 minutes. Groups were convened in the ACT, NSW, SA and QLD.

The meetings focused on variations of the following four questions:

1. What does science in Year 11 and 12 look like in our schools?
2. What should it be like in our schools?
3. What are the factors that work against what it should look like?
4. How can these factors be addressed?

Participants responded to these questions in whole-group discussions. Discussions were audio recorded and transcribed. Participants' reflections were analysed and reported on.

3.2. Sample Parameters for the Student and Teacher Surveys

The sample parameters for the student and teacher surveys were based on school student and teacher population data collected by the Australian Bureau of Statistics (ABS).

Schools were selected from two states, New South Wales and South Australia, and from one territory, the Australian Capital Territory. A stratified random sampling approach was used to select schools. Within New South Wales, the Hunter/Central Coast and Western Sydney regions were selected while the Adelaide region was selected in South Australia. In the Australian Capital Territory the government schools are separate schools for Year 11 and 12 students. These schools are called colleges. The Australian Capital Territory was considered as one region.

All schools with Year 11 and 12 students were listed within each region. From these lists schools were randomly selected to form the sample group for each of the surveys.

The intended and actual sample data for the Teacher Telephone Survey are summarised in Table 3.1.

	Number of Interviews	
Jurisdiction	Intended	Actual
ACT	10	11
NSW	60	62
SA	30	26
Total	100	99

Table 3.1: Intended and actual sample sizes for the teacher telephone survey

The intended and actual numbers of schools sampled for the student survey are summarised by jurisdiction in Table 3.2.

	Number of Schools	
Jurisdiction	Intended	Actual
ACT	6	5
NSW	10	9
SA	7	5
Total	23	19

Table 3.2: Intended and actual numbers of schools sampled for the student survey

3.3. Telephone Survey of Teachers

The purpose of the telephone survey was to identify typical practice in teaching and students attitudes in Year 11 and 12 science. A telephone survey was chosen because of the high response rate and therefore it can remain representative. Because it was interactive it maximised the collection of relevant and valid data. Together with the survey, the telephone surveyors received a random of list of schools, a detailed survey protocol for administering the survey and a clear statement of procedure for contacting teachers. Instruments can be found in Appendix 4.

3.4. Student Survey

The purpose of the student survey was to investigate through a questionnaire students' responses to, and perceptions and ideas about, science at school. The research team developed a draft questionnaire which was forwarded to the Office of the Chief Scientist for feedback. On the basis of this feedback a final questionnaire was prepared. Permission was sought from the educational jurisdictions involved to approve the distribution of the questionnaires to the schools.

The questionnaires, which can be found in Appendices 3.1 and 3.2, contained one page for the non-science student version and four pages for the science student version. In both cases the first section asked for demographic data, such as year level and sex, and instructions for completing the questionnaire. For the science version pages 2 and 3 contained a number of items with a Likert scale rating. The final page was open ended questions. The questionnaire contained a total of 43 items.

The Likert scale questions were prefaced with '*How often do certain things happen during your science lessons at school?'*, or '*How often are these things true?*' Typical items were '*In my science class I copy notes the teacher gives me*' and '*In science I work out explanations with my friends or on my own*'. The five point response scale to items was '*never*', '*once a term or less*', '*about once a month*', '*about once a week'*, and '*nearly every lesson*'.

The final page contained four open-ended questions. Students were encouraged to write about the things they like and don't like about science, how it could be improved and what their intentions were post-Year 12.

The non-science student survey contained two open ended questions and one section of Likert scale ratings, with a total of seven items. The open-ended questions encouraged students to explain why they had chosen not to study science and what their intentions were post-Year 12. The Likert scale questions gauged student attitudes towards the importance of science in everyday life. Typical items were '*Science is relevant to my everyday life*' and '*Science helps me make decisions about my health*'. These questions were also included on the science student survey. The five point response scale to items was '*Almost never*', '*Sometimes*', '*Often*', '*Very Often*' and '*Almost always*'.

The questionnaires were sent to each school divided into packs of 50 copies of the non-science questionnaire and 100 copies of the science questionnaire. Clear instructions accompanied the questionnaires to assist the teachers who would administer the questionnaires in their classes. Appendix 1 contains copies of a letter to the school Principal and the teacher instructions. Parent consent forms were also included in the school packs.

The questionnaires were sent out mid-September. In most cases the return date was delayed due to school holiday periods in September. The return rate for Year 12 students was significantly diminished as many had already left school for the year.

Questionnaires were returned from 19 schools. Only 4 schools of the 23 in the sample did not respond to the survey. One of these schools declined to be involved due to the special nature of their school; a program for young mothers. A total of 1510 usable questionnaires were returned. The science student questionnaire was completed by 1157 students and the non-science student questionnaire was completed by 363 students.

3.5. Case Study

A specialist science and mathematics school in Adelaide was selected and reviewed for the purposes of informing the ideal picture of science education.

4. Summary of Results

The aim of this chapter is to report the data from the focus group meetings, teacher telephone survey, questionnaire survey of students and the case study.

4.1. Focus Groups

The purpose of the focus groups was to discuss teaching and learning while responding to variations of the following questions:

1. What does science in Year 11 and 12 look like in our schools?
2. What should it be like in our schools?
3. What are the factors that work against what it should look like?
4. How can these factors be addressed?

The following summaries have been developed from the focus group transcripts and notes taken during the meetings. This provides a composite picture of the views expressed in each focus group type. Four types of focus groups were conducted:

- Senior science teachers
- Senior science students
- Senior students who had not chosen science subjects
- Community members, including parents, scientists, and representatives from peak science education organisations.

What does science in Year 11 and 12 look like in our schools?

Senior science teachers indicate that Year 11 and 12 science is characterised by overcrowded curricula, significant pressure to cover content in the time available and too much assessment. They are keenly aware that their efforts have the potential to impact their students' university entrance ranking. They feel that there is little time to deviate from the prescribed curriculum to cater for particular cohorts' interests, or to engage students with further exploration and/or application of ideas. Teachers are concerned by the requirement to conduct open or extended investigations in every senior science subject in some jurisdictions. The time demands placed on students is preventing many of them from choosing more than one senior science subject at a time. Teachers also feel burdened by the time and effort required to support students with, and mark the investigations.

> *"In my school students can't do all three sciences [biology, chemistry, physics], the school administration prevents them from doing it because the workload is too much."*

> *"Students study science because it is a prerequisite for [tertiary] courses."*

> *"Students see science as harder so why would [they] pick it in Year 11 and 12 when there is easier subjects on offer."*

> *"[Senior science is] influenced by the teachers that have taken students through high school science."*

Senior science students indicate that the purpose of Year 11 and 12 science is to get into the university course or occupation of their choosing. The majority of students described their reason for choosing science was to meet prerequisite requirements set by universities. A smaller group of students choose to do it because they have not yet decided on their career path and want to keep their options open. A smaller proportion still choose to study science because they enjoy it. Students describe that a typical senior science lesson involves listening to the teacher and taking notes from the whiteboard or PowerPoint slides. There are far fewer hands-on investigation lessons in senior science when compared with junior secondary science. When asked whether senior or junior science more accurately reflects the work of real scientists, students unequivocally indicate that senior science provides the most accurate reflection.

> "*I do physics and chemistry 'cause I'm not sure what I want to do when I leave school and I think they are pretty broad.*"

> "*I like problem solving in physics and I think that helps in broader terms at university*."

> "*In biology we do more hands-on stuff than chemistry and physics*."

> "*We do about five practical lessons in a term*."

> "*We listen to the teacher and read the textbook a lot*."

> "*There is a major difference [between junior and senior science]. In junior they had to make it fun and interesting otherwise we just wouldn't have done it.*"

Non-science students report that senior secondary science is hard, boring and involves lots of formulas and equations. They are not interested in science related careers and, therefore, do not see the value of including science in their subject selection. Many students report that school teachers counsel against choosing science unless they are 'really good at it' or require it as a prerequisite subject. Instead, they are advised to take subjects that are 'easier and require less work'. Some students report that they would like to do science but it clashes with another subject on their timetable.

> "*I failed science in Year 10 and just don't understand it*."

> "*I did well in science at high school but it didn't fit into my timetable in Year 11 and 12*."

> "*Science just got harder and harder… it went from like fun and exciting to like boring and numbers*."

Community members, by and large, hold a very traditional and conservative view of what senior science looks like. Many sense that it is still being taught in a 'chalk-and-talk' manner rather than the more hands-on, inquiry-based approaches often seen in primary and junior secondary science. They predict that a number of students choosing to study science are doing so as they require it for their career aspirations. They also indicated that the falling rates of participation in science reflect the wider range of subjects available in senior secondary school. They imagine an ageing population of senior science teachers, many within five years of retirement.

"When I think of senior science all I can see is students writing vigorously and getting stressed out!"

"I see so many labs full of equipment that never gets used."

"There is a perception that science is hard and only nerdy people do it."

What should it be like in our schools?

Senior science teachers would like uncluttered curricula that encourage 'depth over breadth'. They would like to have time to engage students with the applied and human dimensions of science. They describe that a less-dense curriculum would allow them to design courses that better reflect the work that real scientists do. They would like the issue of compulsory extended investigations to be revisited in those states where it has been mandated.

Senior science students, in large part, are not unhappy with the science they receive and perceive it to be a 'means to an end'. Most display a particular aptitude for science and do not suggest significant changes are required. The fact that it is hard and involves a lot of work is matched by an expectation that it should be rigorous.

Some non-science students report that if science was more 'interesting and relevant to their lives' then they would consider enrolling in it. In one school that had a boarding house, half of the non-science students said they would take agricultural science if it was available at the school. Many, however, think so poorly of their experience and achievement in junior secondary science that they won't consider senior science under any circumstance. This group did, however, appreciate that it was important that others chose science subjects and continued with science related careers. The most commonly cited reason for this was to ensure 'we can find cures and have enough doctors'.

"*There should be levels of science, like medium and hard*."

"*They [the teachers] need to go through more examples and stuff. They need to make sure everyone gets it before they move on.*"

Community members feel that senior science should be fun and designed to attract all students, not just those who require it for career aspirations. It should be largely hands-on and reflect the many and varied occupations involving science. As well as being rigorous it should be engaging and relevant to young people and demonstrate how science understanding and process impacts daily life.

What are the factors that work against what it should look like?

Science teachers report two main factors that work against senior science; over-crowded curricula/assessment and a shortage of trained senior science teachers.

"*The amount of assessment and marking puts good teachers off teaching senior science*."

"*The expectation for an A in chemistry and biology is so much higher now than it used to be*."

"*There are far more options at a school level than there ever have been therefore there's much more competition*."

"*A lot of students really and truly enjoy science, but give them a calculator or algebraic symbols on a page and they melt*."

Since senior science students are largely satisfied with the science they receive, they do not readily articulate inhibiting factors. Several do, however, feel that teachers rush through content and don't take the time required to ensure that everyone in the class understands concepts before moving on. Some also express concern about large class sizes, meaning that a teachers' ability to provided one-on-one assistance is compromised.

"*There is a perception that if you do science then you are going to be working really hard, that probably pushes people away from it*."

"*People don't choose science because it is difficult to get… teachers don't really help the students that don't get it they just suggest they should change subjects*."

"*If you don't need science for your career then there is no incentive to do it.*"

"*If you get behind then it's really hard to catch up… most students just drop out*."

"*Smaller class sizes would mean we could discuss what we were doing with the teacher more*."

"*Teachers should give the same amount of attention to everyone, not just those that do well and ask lots of questions*."

"*Teachers encourage you to do subjects that you are good at rather than subjects that you enjoy*."

"*They [teachers] say don't challenge yourself in Year 12… and science is challenging so lots of people don't do it*."

Non-science senior students report that science is too theoretical and irrelevant for them. The perception that it is very hard was conveyed by older, senior students when they themselves were still in junior secondary. It is not uncommon for low-achieving or disinterested students to be actively discouraged from taking on senior science courses.

"*My teachers told me to only choose subjects that I enjoy*."

"*If people are not interested [in science] then they are not interested… you can't change their mindset.*"

"*If you don't need science for your career then you only need science up to Year 10*."

"*In Year 7-10 we do general science and so we don't really know what biology, physics and chemistry involve when it comes to senior*."

"*All the Year 12s previously said… don't do physics it's really hard… like it's terrible*."

"[Science] should have less writing off the board… I never read through it again."

Community members cite poor teaching and a lack of adequately trained science teachers as significant inhibitors. There is consensus that a good teacher is one who is passionate, knowledgeable and engages students with relevant and interesting examples. That there is an ever decreasing pool of such science teachers in Australia is of great concern to this group.

> "*My course advisor said I wasn't capable of doing Year 11 and 12 science, even though I enjoyed it.*" (comment made by tertiary science graduate who now successfully teaches Year 11 and 12 science courses)

> *"A lot of students disengage with science in Years 7 and 8 because science is taught by the PE teacher [due to a shortage of trained science teachers]."*

> "*If parents didn't have a good experience of science at school then they are unlikely to encourage their children to do it… we need to re-educate parents about the opportunities that science offers, too*."

> "*When I was leaving school and deciding what to do I didn't even consider science teaching, even though I was quite interested in it, 'cause you needed such a low score to get into it. I thought it must be a pretty pathetic job so I set my sights much higher*."

How can these factors be addressed?

Teachers would like to see a reduction in content when the Australian Curriculum: Science for Years 11 and 12 is released. They would like to see a greater effort to attract and retain science teachers to the profession. A close look at establishing appropriate teacher workloads and a revisitation of the requirement to conduct large investigations in senior science subjects is advised.

> "*Senior science needs to be influenced by what is taught in junior high-school. If we are teaching for scientific literacy there, rather than just scientific fact, then we should be doing the same in Year 11 and 12*."

> "*Making science mandatory is not the answer. It would just result in science being taught at a lower level but to more students.*"

> "*Giving them [senior students] an opportunity to do some science without the need for a hard-core scientific background would be good.*"

Senior science students recommend a slower pace of learning and smaller class sizes.

Non-science students do not consider it important to undertake science at the senior level, but do suggest that if it was more applied and not strictly biology, chemistry and physics then more people may be interested. Some suggest that they may have continued with science if their teacher had more time to support them when they were struggling.

Community members would like senior science to better reflect the actual work of scientists and those in applied science professions. They suggest that there should be a focus on recruitment of quality science teachers. That the teacher is the most important resource in the classroom is repeatedly asserted by this group. Ideas for opening students' minds to science are also emphasised, such as career expos and excursions. The important role that parents, teachers and careers advisors play in the subject selection for senior school is also acknowledged. There is a need for the provision of informative and balanced information here.

> "*We need to sell the image of science from an early age*."

> "*If a child has a good grounding [in science] in primary schools and that's picked up again in high school then there will be a flow-on effect from there…*"

4.2. Teacher Telephone Survey

A total of 99 telephone surveys were completed in New South Wales, Australian Capital Territory and South Australia. The breakdown of surveys by each jurisdiction can be found in Table 4.1.

State/Territory	Proportion of sample (%)
ACT	11%
NSW	63%
SA	26%

Table 4.1: Proportion of teacher telephone surveys by state/territory

Within each jurisdiction, a sample from each of the Catholic, Independent and State sectors were selected, as per Table 4.2.

Sector	Proportion of sample (%)
Catholic	14
Independent	26
State	60

Table 4.2: Proportion of teacher telephone surveys by sector

The gender of the teachers surveyed was almost evenly split, as represented in Table 4.3. The gender of one respondent was not recorded.

Gender	Proportion of sample (%)
Male	51
Female	48

Table 4.3: Proportion of teacher telephone surveys by gender

When asked which senior science subjects they taught, some teachers indicated more than one discipline, so the total exceeds 100%. The subject with the largest percentage of teachers was Biology, closely followed by Chemistry. Psychology was taught by the smallest number of teachers. See Table 4.4.

Subject Taught	Proportion of teachers interviewed (%)*
Agriculture/Horticulture	5
Biology	45
Chemistry	43
Earth Sciences	6
Physics	39
Psychology	2
Senior/General Science	16

Table 4.4: Senior subjects taught by teachers interviewed
(*Total exceeds 100% as many teachers taught more than one subject)

Estimated Percentage of School Population Studying Science

Teachers were asked to estimate the percentage of senior secondary students studying science at their school. Many teachers found this difficult question to answer. Because many students study more than one discipline, class numbers alone were an unreliable source of information. Answers ranged from 5% to 90%. An average of the responses was taken, with teachers across all schools estimating 45% of students are studying science.

Teachers' Science Qualifications

Teachers were asked if they had a science qualification. About three-quarters (75%) indicated they had studied a Bachelor of Science. Teachers were asked what their major area of study was, with 20% saying Biology, 15% Physics and 14% Chemistry. The remaining 40% had majored in different areas. Some teachers (28%) indicated they had a different science qualification, such as a Masters degree or a Bachelors degree in a different science. This group comprised both teachers who had completed a Bachelor of Science and other teachers who had not. Only 7% of surveyed teachers did not have a specific science qualification.

Most Popular Science Subject

When asked which science subject is the most popular at their school, most teachers (77%) said Biology. Chemistry was most popular in 17% of schools. See Table 4.5.

Most popular subject with students	Teacher response (%)*
Biology	77
Chemistry	17
Senior/General Science	7
Physics	5
Psychology	4
Earth Sciences	2

Table 4.5: Teachers reporting on which subjects were most popular at their schools
(*Total exceeds 100% as some teachers listed more than one subject)

Teachers were also asked why they think the subject is the most popular in their school. The most common response (58%) was that students perceived the subject to be easier than the other science options, or involving less maths. This reason was most commonly attributed to students choosing Biology. Some 27% of teachers suggested students were choosing subjects based on prerequisites for university courses or to help them towards their chosen career path. These and other responses are included in Table 4.6.

Reason given for subject popularity	Teacher response (%)*
Easier or less academic	58
Career goals or university prerequisites	27
Other	17
Relevant to their lives	15
Enjoyment or interest	15
Teaching staff	11

Table 4.6: Teacher explanations for popularity of subject
(*Total exceeds 100% as some teachers gave more than one reason)

Approach to Teaching Science

Teachers were asked what the common approaches to teaching science were at their school. Many teachers mentioned more than one approach. The frequencies of the responses have been listed in Table 4.7.

Common approach to teaching	Teacher response (%)*
Technology or computers	43
Chalk and talk or teacher directed	40
Notes, workbooks or textbooks	25
Practicals	57
Research	13
Investigations	18
Discussions, literacy activities or group work	25
Other	8

Table 4.7: Common approaches to science teaching
(*Total exceeds 100% as many teachers gave more than one response)

Assessment Methods

When asked about what methods they commonly used for assessment, almost all of the respondents mentioned written exams or tests (97%). Practical exams (88%) were also common, as were research assignments (66%). Fewer teachers said they use investigations and other assessment methods such as oral presentations. See Table 4.8.

Common method of assessment	Teacher response (%)*
Exams or tests	97
Practical exams	88
Research assignments	66
Investigations	28
Other	20

Table 4.8: Common approaches to assessment
(*Total exceeds 100% as many teachers commonly use more than one assessment method)

Some teachers mentioned the fact that the syllabus was very prescriptive in what methods of assessment they should use. This was a particularly common response from teachers in South Australia, who indicated that there is very little choice for teachers as to how they assess their students.

Reporting to Parents

Grades are the most common way assessment information is reported to parents, with 60% of schools using this method. Other popular reporting formats included marks/percentages (44%) and comments (43%). See Table 4.9.

Method of reporting to parents	Teacher response (%)*
Grades	60
Ranks	24
Percentages or marks	44
Comments	43
Outcomes	22
Other	4

Table 4.9: Method of reporting to parents
(*Total exceeds 100% as more than one method of reporting used)

Factors Limiting the Teaching of Science

The most common responses teachers gave when asked what limits their teaching of science were related to time, with 36% of teachers mentioning this. This was mentioned in several different contexts, such as a lack of time for preparation, insufficient class time to get through the required syllabus, and interruptions to the timetable because of extracurricular activities. A lack of resources was mentioned by 23% of respondents. This was generally in relation to laboratory equipment. See Table 4.10.

Limiting factor to teaching science	Teacher response (%)
Time restrictions, including too much content or interruptions from extracurricular activities	36
Student motivation	15
Resources or money	23
Low student literacy and other skill development in junior secondary	4
Other	18

Table 4.10: Factors which limit the teaching of science identified by teachers

Improving the Quality of Science Teaching

There were varied responses when teachers were asked about how they might improve science teaching in their school. As with the previous question, resources were mentioned by many teachers. This included access to resources and programs such as university laboratories. Time was mentioned in relation to time for collaboration and other contexts similar to the previous question. Professional development was also a common response. Topics for professional development were as broad as using technology in the classroom, general pedagogy/teaching strategies and keeping up to date with the latest scientific news to include in their lessons. Some teachers recognised the importance of student attitudes in their classes. Teachers mentioned the difficulties involved with having students in the class who had to be there for whatever reason rather than wanting to learn science. See Table 4.11 for full results.

Strategy to improve science teaching	Teacher response (%)
Improving teacher knowledge and skills	18
Student motivation or inappropriate subject selection	12
Preparation in junior years	4
Time for planning or time in class	19
Resources	20
More inquiry-based teaching or use of technology	7
Smaller classes	3
Other	14

Table 4.11: Strategies for improving science teaching identified by teachers

4.3. Student Surveys

Two different student surveys were conducted—one for students taking science and one for students taking no science classes. The science student questionnaire was completed by 1157 students and the non-science student questionnaire was completed by 363 students.

4.3.1. Non-science Student Survey

Of the students not studying science, 45% of respondents were male and 55% female, with one student not providing their gender. Year 12 students made up 31% of the sample and Year 11 68%, with 1% not providing their year.

Mathematics

Students were asked to list the subjects they were studying. Of this sample, 74% were studying mathematics at some level. An analysis of how many students had chosen high level mathematics rather than a lower level course was not possible because many students reported that they were taking 'maths' rather than specifying their course.

Why Students are not studying science

When asked why they chose not to study science, the most common response from students was that they disliked it or it was boring (61%). Another common theme mentioned by 31% of students was that they found science hard to understand or that they are not good at it. Some students (26%) indicated that they did not feel they needed to study science for their careers. However, there were a portion of students who indicated they would have liked to study science (6%). These students gave reasons such as timetable clashes and advice from teachers as to why they did not choose science subjects. 2% of students said they had chosen science classes but since dropped out.

What students intend to do after school

Students provided a variety of responses about what they intend to do when they have finished school. Studying at university was the most common response, with 48% of students mentioning this. Work was another common response (20%), as was study at TAFE or entering a trade (14%). A small percentage (10%) said they did not know what they would do after Year 12 and 7% gave other responses such as joining the defence forces or travelling. No response was provided from 1% of students.

Perceived relevance of science

Students were asked to indicate how relevant science was to various issues in their lives and general society. Students do not feel science is particularly useful or relevant to them personally. However, about three-quarters of respondents recognise the importance of science to Australia's future. See Table 4.12 for responses.

	Response (%)				
Item	Almost never	Sometimes	Often	Very often	Almost always
Science:					
is relevant to my future	42	37	14	4	1
is useful in everyday life	18	42	24	9	4
helps me understand decisions about my health	19	31	26	17	6
helps me understand environmental issues	12	29	30	20	7
is important to Australia's future	7	15	23	24	29

Table 4.12: Student responses when asked how relevant science is in a variety of contexts

4.3.2. Science Student Survey

Of the students studying science, 52% of respondents were male and 46% female, with 1% not providing their gender. Year 12 students made up 38% of the sample and Year 11 61%, with 1% not providing their year.

Subject choice

Students were asked to list the subjects they were studying. Respondents studied an average of 1.55 science courses each, with 2% of students not indicating which subjects they were studying at the time.

Biology was the most popular science subject, closely followed by Chemistry and Physics. Less popular subjects included Agricultural Science, Earth Sciences and Psychology. Other sciences, such as Nutrition, were studied by a small number of respondents. See Table 4.13.

Subject	Students enrolled (%)*
Agriculture	2
Biology	47
Chemistry	44
Earth Science	6
General Science	7
Physics	34
Psychology	10
Other Science	2

Table 4.13: Subject choices of students studying science
(*Total exceeds 100% as some students are enrolled in more than one science subject)

Mathematics

A total of 79% of respondents indicated they were studying Mathematics. Of this group of students, 41% were studying high level mathematics, 19% were studying low level mathematics and the remaining 39% did not specify which mathematics course they were studying. Some students only listed the science subjects they were studying and not the other subjects they had chosen. The number of students to have chosen mathematics may be higher than the 79% reported.

Why students are studying science

When asked why they chose their science subjects, more than half of respondents mentioned an interest in the subject or indicated it was relevant to their lives. More than a third of students were thinking about their future career or university study and some of the students chose their subjects because they were good at them or they thought they were easier than other subjects. See Table 4.14.

Reason for choosing science	Student response (%)*
No response	2
Career or university	38
Teaching staff	1
Easier or less mathematics than other science subjects; aptitude	12
Interest or relevance; fun	68
Other	11

Table 4.14: Reasons given by students for studying science
(*Total exceeds 100% as some students gave more than one reason)

Becoming Interested in Science

Junior secondary school was the response nearly half (48%) of students gave when asked when they became interested in science, with a few mentioning primary school. Almost one-fifth of students said they had always been interested.

More than a third did not give a specific response to the second part of the question about how they became interested. Many of these non-responses can be attributed to students who said they have always been interested in science and therefore felt no need to indicate how they became interested. Similarly students who indicated they were not interested in science generally gave no response to this part of the question. Activities or lessons at school, including specific teachers, enrichment programs and subject information nights, were the most common responses. See Table 4.15.

When did you become interested in science?	Student response (%)	How did you become interested in science?	Student response (%)
No response	14	No response	36
Junior secondary school	48	School-based activities including enrichments programs and subject information evenings	49
Primary school	12	TV, books or other media	6
Always	16	Family member	5
Not interested	7	Other	4
Other	4		

Table 4.15: Student responses to when and how they became interested in science

What students like about their science classes

The most common responses from students when asked what they liked about their science classes were related to the content. Some mentioned specific content such as 'anatomy' and others mentioned how they liked learning how things work or about everyday facts. Another common theme was the atmosphere in the class. This included comments about the teacher, classmates and the general mood in the classroom. Practicals, excursions and investigations were also mentioned. 5% of respondents did not answer this question. See Table 4.16.

What are the things you really like about science in your class?	Student response (%)*
No response	5
General class atmosphere, including the teacher and fellow classmates	35
Class discussions	14
Practical activities, excursions and investigations	27
Specific content	47
Other	5

Table 4.16: Frequency of student responses to what they liked about their science classes (*Total exceeds 100% as some students cited more than one feature)

What students don't like about their science classes

When asked what they didn't like about their science classes, over a third of responses were related to the content. These included comments that it was boring or difficult and some students mentioned specific content they did not enjoy, such as 'stoichiometry'. Note-taking and textbook work was a problem for some students as was there being too much content to cover in a short amount of time. 9% of respondents did not answer this question and 9% stated that there was 'nothing' they disliked about science in their class. See Table 4.17.

What are the things you don't like about your science class?	Student response (%)
No response	9
Too much content; too little time to learn	10
Note taking; homework; textbooks	17
Specific content; boredom; difficult content	34
Student behaviour	8
Teacher input including teaching style	3
Nothing	9
Other	11

Table 4.17: Frequency of student responses to the things they don't like about their science class

What could be done to improve science classes?

When asked about how their science classes could be improved, the most common suggestions related to making it more interactive through, for example, investigations, excursions, practical lessons or class discussions. The role of the teacher was important to many students. This included improvements in teaching styles and using different resources. Reducing the amount of content in the syllabus was mentioned as were aspects of personal improvement. See Table 4.18.

How could your science class be improved so that you could learn more?	Student response (%)
No response	22
Personal application such as more study	6
Classroom management	4
Less content to cover	10
Make lessons more interactive such as through activities, excursions and discussions	30
Teaching style; teacher resources	19
Other	10

Table 4.18: Frequency of student responses to how science classes could be improved

What students intend to do after school

More than half of respondents indicated they intended to study at university after completing Year 12. Of these, 41% indicated they would choose a science-related course (25% of the total sample). The other students either mentioned a non-science-related course of study or did not specify which subject they would study. 6% gave no response to this question. See Table 4.19.

What do you intend to do after Year 12 regards work or study?	Student response (%)
No response	6
University—science-based course	25
University—other/not specified course	39
Work—science-based job	2
Work—other/not specified job	10
TAFE/trade	3
Don't know	10
Other	5

Table 4.19: Post-school intentions of student survey sample

Learning activities—dealing with content

Item	Response (%) Never	Once a term or less	About once a month	About once a week	Nearly every lesson
In my science class:					
I copy notes the teacher gives me	1	3	4	17	73
I work out explanations in science with friends or on my own	1	2	13	39	44
I have opportunities to explain my ideas	2	6	13	32	45
I read a science textbook	7	11	21	33	27
we have class discussions	1	3	9	25	61
we do our work in groups	2	6	20	45	25
In science we:					
investigate to see if our ideas are right	8	16	32	30	12
My science teacher:					
lets us choose our own topics to investigate	32	33	20	8	6

Table 4.20: Frequency of learning activities identified by students

Table 4.20 covers the learning activities that students experience in their science classes. Copying notes from the teacher is the most common activity reported, with 73% of the sample saying they do it nearly every lesson. Discussions in small groups and as a class were also reported to be regular occurrences. Student direction in investigations was not as common, with 33% of students claiming they chose their own topics once a term or less, and 32% saying they never chose their own topics.

Learning activities—practical work

Item	Never	Once a term or less	About once a month	About once a week	Nearly every lesson
	Response (%)				
In my science class:					
I watch the teacher do an experiment	5	14	33	29	17
we do experiments by following instructions	2	7	26	35	27
we plan and do our own experiments	14	27	31	18	8

Table 4.21: Frequency of practical tasks identified by students

Table 4.21 reports on the practical activities in senior science classrooms. More than half of students report doing experiments at least once a week. However, the practical activities carried out by students are often 'recipe style' practicals. Only 26% of the sample reported planning and doing their own experiments at least once a week.

Thinking about science

Item	Almost never	Sometimes	Often	Very often	Almost always
	Response (%)				
In science we need to be able to:					
think and ask questions	1	3	13	31	51
remember lots of facts	1	5	18	36	40
understand and explain science facts	1	3	14	32	50
recognise the science in the world around us	1	6	18	32	41

Table 4.22: Thinking skills required for science as identified by students

Students report in Table 4.22 that they are required to think about science most of the time in class. Between 73 and 82% of students said they must be able to ask questions, remember and explain facts and see the science in the world around them very often or almost always.

Teacher feedback and guidance

Item	Response (%) Never	Once a term or less	About once a month	About once a week	Nearly every lesson
My science teacher:					
tells me how to improve my work	3	7	21	35	33
gives us quizzes that we mark to see how we are going	12	19	32	21	13
talks to me about how I am getting on in science	8	22	32	23	12
During science classes:					
we have enough time to think about what we are doing	3	20	32	31	13

Table 4.23: Frequency of feedback and guidance from teacher as indicated by students

Frequency of feedback and guidance from the teacher is reported in Table 4.23. Formative assessment in the form of quizzes and discussion with the teacher occurs at least once a month for about 70% of students. However, 8% of students said their teacher never talks to them about how they are going in class. Only 13% of students feel they always have enough time to think about what they are learning.

Links with secondary school science outside the classroom

Item	Never	Once a term or less	About once a month	About once a week	Nearly every lesson
	Response (%)				
In my science class:					
we learn about scientists and what they do	8	21	30	26	13
In science we:					
do practical work outside in the schoolyard, the beach or in the bush	32	46	16	3	1
have excursions to the zoo, museum, science centre or places like that	38	55	4	1	1
have visiting speakers who talk to us about science	56	34	7	1	1

Table 4.24: Frequency of links outside the science classroom as reported by students

Table 4.24 indicates that students rarely have opportunities to study science outside of their classrooms. Only 4% say they do practical work outside once a week or more. Similarly, visiting speakers are rare, with more than half of students indicating they never have this experience. Learning about scientists is more common, with 13% reporting this happening nearly every lesson.

Computer use in science

Item	Never	Once a term or less	About once a month	About once a week	Nearly every lesson
	Response (%)				
In science we:					
use computers to do our science work	12	18	35	23	10
look for information on the internet at school	8	16	33	29	11

Table 4.25: Computer use in science class as identified by students

Table 4.25 reports on how often students use computers in their science classes. About three-quarters of students use computers in their science classes once a month or more. Similarly, one quarter report never using the internet for research, or less than once a month.

Enjoyment and curiosity in science

Item	Response (%) Almost never	Sometimes	Often	Very often	Almost always
During science lessons:					
I get excited about what we do	7	26	31	19	15
I am curious about the science we do	3	16	26	29	25
I am bored	24	49	12	8	7

Table 4.26: Attitudes towards learning science as identified by students

Year 11 and 12 science students generally have a positive attitude to learning science, as shown in Table 4.26. More than half are almost always or very often curious about what they are learning. Only 7% never get excited and only 7% are almost always bored.

Perceived difficulty and challenge of science

Item	Response (%) Almost never	Sometimes	Often	Very often	Almost always
During science lessons:					
I don't understand the science we do	27	50	11	6	4
I find science too easy	39	41	10	5	2
I find science challenging	4	25	31	26	12
I think science is too hard	35	42	11	6	4

Table 4.27: Perceived difficulty or challenge of science as indicated by students

The data in Table 4.27 indicate that senior science is neither too easy nor too hard for the majority of students. Almost two-fifths of students find it challenging very often or almost always and 10% say they don't understand the science very often or almost always.

Perceived relevance of science

Item	Response (%)				
	Almost never	Sometimes	Often	Very often	Almost always
Science:					
is relevant to my future	9	19	17	21	33
is useful in everyday life	5	25	27	23	19
helps me make decisions about my health	12	24	25	22	16
helps me understand environmental issues	5	13	26	31	24
is important to Australia's future	3	8	15	27	47

Table 4.28: Relevance of science as perceived by students

Table 4.28 shows that there is a broad range of views among students about how relevant the science they learn in class is. About 10% of students say science is almost never relevant to their future and almost never guides their decisions about their health. Regarding students' health and the usefulness of science in everyday life, the most common response was that science is often helpful. The remaining students were approximately evenly divided between it being useful more often and less often.

4.4. Case Study

The Australian Science and Mathematics School (ASMS) is a specialist public school in Adelaide that caters for the final three years of schools, Years 10, 11 and 12. It operates from a purpose built facility located on the Flinders University campus. The school promotes and supports 'highly collaborative, interactive student-directed learning within an innovative curriculum' (ASMS, 2011).

This school has been selected as a case study site due to its innovative program and established success in attracting and retaining students. The mission, principles and curriculum of the school represent a practical application of best practice as reported in the science and mathematics education literature. For example, many of the recommendations made in the Goodrum, Hackling & Rennie (2001) review of science education in Australia are evident in the practices and programs of the ASMS.

The ASMS is not an academically selective school. Rather, it selects students against a range of set selection criteria. These criteria include interest and passion in studying and perusing pathways in science and mathematics, evidence of aptitude or ability and an understanding of personal learning style.

The school's Context Statement outlines the following:

> "*The ASMS serves as a state wide focal point for teaching and learning, professional development and research aimed at fostering improvement, innovation and reform in Science and Mathematics education. The school provides new ways of teaching and learning in Science and Mathematics through the creation of an environment for interaction between educators and professional scientists and mathematicians within institutions and industry in South Australia and beyond. The schools' partnership with Flinders University is its main source of interaction*." (ASMS Context statement, 2011)

Teaching and learning at the school is governed by seven key principles. Many of these principles are unique in a secondary school setting. An analysis of these principles helps to define the nature of the learning experience offered to students of the ASMS. The principles are (as adapted from the ASMS Context statement, 2011):

1. *New Sciences:* ensuring emerging areas of science such as nanotechnology, aquaculture, biotechnology, photonics, genomics, polymer science, robotics and communication technologies are incorporated into school curriculum.
2. *Inquiry Learning:* ensuring students engage in deep study in personal projects of major significance, especially through problem based and inquiry based learning approaches.
3. *Interdisciplinary Curriculum:* building programs with a focus on scientific and mathematical processes in ways that are closely linked with learning from all areas of study.
4. *Standards of Significance:* providing a systematic approach to allow students to meet school, state-wide, national and international educational standards.
5. *Authentic Experience:* allowing students to study real world ideas, problems and issues and to make connections with their learning that are meaningful to them in their present and possible future life circumstances.
6. *Engagement and Retention:* providing an impetus that increases participation and success of senior secondary students in science, mathematics and related technologies and transforms students' attitudes to science and mathematics as career paths.

As outlined above, the school adopts an inquiry-based approach to education. Inquiry-based learning activities are designed to strengthen and deepen the students' learning in a subject through the exploration of interesting questions. 'This process allows students to make choices that interest them, the opportunity to learn deeply and *challenge and motivate* them to find ways to make a difference' (ASMS, 2011). There are many opportunities for students to learn how to collaborate with peers and others to learn effectively.

The learning program for students in Years 10 and 11 at the ASMS is based on the unique courses developed by the school called Central Studies. There are three separate Central Studies presented in each semester over a two year program. There is also a Special Inquiry Project presented as a specific unit of study in the second semester of each year. Interrogation of the Central Studies programs illustrates the cross-disciplinary, or interdisciplinary, nature of the curriculum. Rather than the traditional subjects of Biology, Physics, Chemistry and Mathematics, each of these are taught in context across a range of courses. Table 4.29 outlines the Central Studies program for 2010 and 2011.

Semester 1 (2010)	
Mathematics and Abstract Thinking – Patterns of Change (1)	This unit focuses on the mathematical concept of function with investigations related to the areas of sequences and series, finite differences, polynomial, exponential, logarithmic and periodic functions.
Biodiversity	This study involves the understanding of the diversity of life on planet Earth through the role of evolution in the development of species. Major areas of investigation include geological time scales, natural selection, Earth processes such as continental drift and plate tectonics, dating methods and the extinction of species. Other concepts and content include animal and plant structure and function, ecosystems, biodiversity and classification systems.
Towards Nanotechnology	Nanotechnology is the science of working directly at the atomic and molecular level and its potential to greatly change the world in which we live. This study involves the understanding of materials and their properties at macro and micro level and will move towards an understanding of the potential of nanotechnology. Applications and challenges include the working of lasers, fibre optics, communications and the creation of molecular machines to manufacture safer chemicals, detect and remove pollution and for the diagnosis and cure of disease.
Semester 2 (2010)	
Mathematics and Abstract Thinking – Modelling Chance and Space (1)	This unit focuses on developing mathematical capability and inquiry skills in the areas of probability, statistics, geometry and measurement.
Biotechnology	This study begins by considering how to use natural processes such as genetics and selective breeding to improve fermentation, crop yield and disease resistance to best advantage. Key concepts and content include cell physiology and function, using proteins and the immune system to assay plant and animal health and the interplay between microbiology, public health and the environment. Other content and concepts include the analysis and use of DNA markers and fingerprinting, genetic modification, gene technology and bioinformatics.
The Earth & the Cosmos	This study explores understandings of the sun, moon and stars and their social, spiritual and technological roles. The concepts and content covered include the structure and size of the universe, understandings of time and space, composition of the planets, evolution of the Earth’s atmosphere, oceans and geological formations and space exploration. Computer simulation and mathematical modelling of physical phenomena will enhance students’ understandings.

Special Inquiry Project	In the Special Inquiry Project students undertake a detailed self-directed study in an area of interest. The Special Inquiry Project promotes the development of research, investigation and inquiry skills as well as the skills and abilities connected with organising and managing a sustained independent work effort. The Special Inquiry Project can be related to and build on works in an existing area of study for the student, or can be with a separate declared area of interest.
Personal Learning Plan	The Personal Learning Plan is designed to help students make informed decisions about their personal developments, education and training. At the ASMS much of the development work of the Personal Learning Plan is done through the Tutor Group program across Years 10 and 11. Students have the opportunity to demonstrate their standard of achievement with aspects of the Personal Learning Plan through the Learning Conversations conducted in Term 1 and 3 each year.
Semester 3 (2011)	
Mathematics and Abstract Thinking – Patterns of Change (2)	This unit focuses on the mathematical concept of function with investigations related to the areas of sequences and series, finite differences, polynomial, exponential, logarithmic and periodic functions.
The Body in Question	In this unit students study fundamental science concepts such as the nature of disease causing organisms and the response of the human body to stress. Students investigate the impact of physical forces such as extreme motion on the body. Students also investigate human health issues through local and global perspectives
A Technological World	In this unit students investigate various social impacts of developments in science and technology over time. There is a particular focus on understanding developments in the uses of energy and materials over time and the social implications of these developments.
Semester 4 (2011)	
Mathematics and Abstract Thinking – Modelling Chance and Space (2)	This unit focuses on developing mathematical capability and inquiry skills in the areas of probability, statistics, geometry and measurement.
Communication Systems	In this unit students investigate how humans exchange, interpret, change, adapt, transform and control information and communications. There is a detailed focus on the physics of electrical communication to understand electrical currents and micro processors, and the chemistry of biochemical communication to understand the structure and function of chemicals such as neurotransmitters and hormones.
Sustainable Futures	In this unit the sustainability of the Earth is explored in concert with human systems and human behaviour. Topics of interest include population studies, food production, water quality and availability, waste management, environmental chemistry and bioremediation. Students are encouraged to undertake investigations that look at the use of technologies to counter degradation and promote sustainable practices.

Special Inquiry Project	In the Special Inquiry Project students undertake a detailed self-directed study in an area of interest. The Special Inquiry Project promotes the development of research, investigation and inquiry skills as well as the skills and abilities connected with organising and managing a sustained independent work effort. The Special Inquiry Project can be related to and build on works in a existing area of study for the student, or can be with a separate declared area of interest.

Table 4.29: ASMS Central Studies program for 2010-2011

The Central Studies program has been accredited by the South Australian Certificate of Education (SACE) Board.

Upon completing Year 12, a large majority of students select tertiary course which reflect the focus area of the ASMS. Of the 71 students graduating in 2010 who enrolled at university, 76% chose science and or mathematics related courses (ASMS 2010 Annual Report, 2010). See Table 4.30.

Area of study	%
Science	29.6
Engineering	15.5
Technology	12.7
Health	18.3
Business	14.1
Arts	9.8

Table 4.30: Tertiary areas of study chosen by 2010 ASMS graduates

5. Expectations for Year 11 and 12 Science – the Ideal

The purpose of this chapter is to draw together the main ideas that represent the consensual picture of an ideal science teaching and learning for Year 11 and 12 Australian schools. In their review of Australian school science, Goodrum, Hackling and Rennie (2001) identified a number of themes to depict the "ideal" science education. The evidence gathered through the course of this study indicates that this picture remains current and further has international support (Gilbert, 2004). It is also consistent with the aspirations of the Australian Curriculum: Science (ACARA, 2009).

The themes from the original 2001 study have been adapted and modified slightly to the specific needs of Year 11 and 12. These themes have also been grouped around four major focus points: students, teachers, resources and values.

5.1. Students and their Curriculum

Theme 1: The science curriculum is relevant to the needs, concerns and personal experiences of the students.

Theme 2: The teaching and learning of science is centred on inquiry. Students investigate, construct and test ideas and explanations about the natural world.

Theme 3: Assessment serves the purpose of learning and is consistent with and complimentary to good teaching.

Comments

These themes are derived from the belief that in Year 11 and 12 there is too much content that reinforces a transmission model of teaching and a narrow rigid examination system. This examination system of assessment tends to result in an emphasis on memorisation rather than genuine learning. Learning in this case is considered to be worthwhile when it is applied to new situations in a meaningful way. For learning to be meaningful, science concepts should be taught in a context that is relevant based on the experiences of the student. The Australian Curriculum: Science recognises these themes and attempts to embed them in senior science courses that are being developed.

These themes also imply there should not be a tension between teaching science for 'scientific literacy' and meeting the needs of students who wish to pursue a science related career at university. If a student learns science concepts in a context that is meaningful then that learning is intrinsically useful no matter what career pathway a student undertakes. Just because a student decides to seek a science related career that does not mean the science he or she is taught needs to be boring, irrelevant or lacking a sense of joy. The science concepts that students learn may be challenging but they should be achievable. They should also enhance personal and social decision making.

5.2. Teachers and their Profession

Theme 4: The teaching-learning environment is characterised by enjoyment, fulfilment, ownership and engagement in learning and natural respect between teacher and students.

Theme 5: Teachers are professionals who are supported so that they can reflect and build the understanding and competencies required of best practice.

Theme 6: Teachers of science including Year 11 and 12 have a recognised career path based on sound professional standards endorsed by the profession.

Comments

Every student wants a teacher who is enthusiastic, motivated, well trained and focused on meeting their needs. Science teaching is a rewarding but dynamic and demanding profession. The escalating knowledge in science, the ever widening access to information through different technologies and the ever changing political and social influences continually challenge and pressure teachers to continually upgrade their professional learning.

5.3. Resources for Teaching and Learning Science

Theme 7: Excellent facilities, equipment and resources support teaching and learning.

Theme 8: Sufficient time is available by which teachers can prepare, teach and assess student science learning.

Comments

Besides the obvious importance of having relevant equipment for an inquiry-based science curriculum, teachers of science also require support staff to assist in the preparation and organisation of materials for science activity. Time presents significant pressures for both teachers and students. In an ideal world there should be sufficient time for students to learn and teachers to teach. For this to occur, decisions need to be made about what can be realistically accomplished in the time available. Strategies also need to be developed by which the available time is used wisely.

5.4. The Value of Science Education

Theme 9: Science and science education are valued by the community, have high priority in the school curriculum and science teaching is perceived as exciting and valuable, contributing significantly to the development of persons and to the economic and social well-being of the nation.

Comments

The current debate on climate change has shown the importance of quality science in our community. There is an increasing realisation that many of the decisions we make both at the social and personal level require good evidence and good science. To make these decisions, people need to be scientifically literate. Hence there is a need to value science education.

6. The Actual Picture

The research design intended to establish two pictures: the ideal that outlined our expectations and the actual that is the reality of what is happening in Australian Year 11 and 12 science classrooms. To determine this real picture, data has been gathered from recent reports, international studies, focus group discussions with students, teachers and community members, surveys of students and telephone interviews with teachers. This collected data provides the basis for triangulation and comparison. The resulting picture is complex, with some surprising and even contradictory aspects. The picture is painted by focusing on different dimensions of the school experience: the students, the curriculum, the pedagogy, the teachers and finally the resources.

6.1. The Students

One of the surprising results is the dramatic fall in the collective number of students studying science. While there was a general appreciation that less students were studying physics, chemistry and biology, the overall drop in science study as a whole is quite staggering. In the early nineties, nine out of ten students in Year 12 studied science. Today, that figure has shrunk to half the Year 12 cohort.

The majority of students who study science still do the traditional disciplines of biology, chemistry and physics in that order of popularity. There has been a slight increase in the other sciences, especially the subject of psychology. This subject is mainly taught in Victoria, with some enrolments in South Australia and Western Australia.

The decision by students to enrol in Year 11 and 12 science courses is made for the most part during the lower secondary years. While there are a variety of factors that affect this decision the two most dominant influences appear to be an interest in science based on the science experienced during Years 7-10 and the future aspirations of the students.

The decreasing number of students wishing to study science would indicate that there is declining interest in science for students. The apparent contradiction is that for those students who study science at Year 11 and 12 they enjoy science. This was clearly evident in the focus group but also reinforced in the student survey. Two thirds of Year 11 and 12 science students indicated they often, very often or almost always are excited by the science they do. Furthermore, 82% are often curious about the science they study. However, it should be noted that almost half are sometimes bored by the science.

While there is no information by which to reliably compare the science achievement of Year 11 and 12 students, the available data for 14 and 15-year-old students is of a concern. The PISA results for 15-year-olds and the TIMSS data for Year 8 students paint a similar picture. The science achievement for Australia reported through PISA would appear to have remained the same while for other countries there have been improvements. TIMSS would suggest student achievement is falling. It should be noted that while the Australian results are above the average for each study, the underlying trend is still of concern.

The general picture that emerges is that fewer students are studying science but these fewer students enjoy the science they experience and it is in keeping with their expectations for the future. Science students have a very positive view about science and its importance in broader society.

Students who do NOT study science in Years 11 and 12 largely do so because they dislike it or find it boring. This perception is based on their experiences in junior secondary science. Many report that they are actively advised by their school not to take science unless they are good at it or require it as a prerequisite subject.

Almost three-quarters of non-science students agree that science is important to Australia's future, with finding cures for disease cited as the most common reason. However, very few perceive science as important, relevant or useful in their own everyday lives.

6.2. The Science Curriculum

National reports and the literature describe two different perspectives for science curricula. One perspective takes the position that the purpose of the science curriculum is to promote scientific literacy. The other perspective is that school science is essentially a preparation for university science study. The view of teachers and students as derived from the surveys and focus groups is that Year 11 and 12 science is constructed to prepare students for university study.

This university preparation perspective has resulted in an overcrowded content-laden curriculum. With the amount of content to be covered there is little room for flexibility from either the teacher or student. The science courses are perceived to be conceptually difficult with an emphasis on theoretical abstract ideas. The courses which have a quantitative dimension like physics and chemistry are considered the most difficult subjects of all. Biology is the most popular because it is perceived to be easier.

One of the surprising aspects is that a number of students are discouraged from studying science because of its perceived difficulty. Students were encouraged to study subjects that were considered easier and hence would maximise their final results for university entrance.

While half of students (47%) listed specific content as the reason why they liked science in the open question they were asked, 34% of students also indicated that what they did not like about science was the difficult or boring content. Interestingly, 94% of Year 11 and 12 science students perceived that their science is often, very often or always about remembering lots of facts. Almost three-quarters of students (69%) find their science often, very often or always challenging and 39% never find their science too easy. This is balanced by 35% who never find it too hard.

6.3. Science Teaching and Learning

The content-laden curriculum encourages science in Year 11 and 12 to be taught in a traditional way using the transmission model. The transmission model assumes that students know little and the role of the teacher is to fill their heads with new facts and knowledge.

This approach is revealed by the fact that 73% of science students indicated that they spend every lesson copying notes from the teacher while 65% never or seldom have choice in pursuing areas of interest. Teacher demonstrations are common, with 79% of science students suggesting this occurs often, very often or always in a lesson. The practical work tends to be ‘recipe based’ with students required to follow specific instructions to achieve known results.

In some states there are assessable open-ended student investigations. From the focus group discussion with teachers there was a concern about these investigations. The investigations were placing significant demands on both students and teachers.

With the emphasis on content, assessment was also an issue. It tended to be summative with a focus on students memorising facts for the test.

Most of the science learning was classroom-bound. The students had few opportunities to engage in activities outside the classroom. Most students never or seldom did practical work outside the classroom (78%), went on excursions (93%) or had visiting speakers (90%).

6.4. Year 11 and 12 Science Teachers

The supply and demand issues that affect secondary science teachers appear to have had minimal impact on Year 11 and 12 science at this point in time. This may be as a result of the decreasing number of students who are studying science in Year 11 and 12.

Science in Year 11 and 12 is taught by the most qualified and most experienced science teachers. In the telephone survey, three quarters of the interviewed teachers indicated they had a Bachelor of Science. Only 7% had no science qualifications. These figures are in common with other surveys (McKenzie *et al*, 2008).

6.5. Resources

The content heavy curriculum puts significant pressure on teachers as they attempt to help their students. Within this pressure situation, time becomes an important resource for both students and teachers. The most common factors that teachers listed as limiting their teaching were time (36%) and resources (23%).

For students engaged in hands-on activities, the support of a laboratory technician becomes important. In a recent study (Hackling, 2009), there were 11% of schools with secondary students that did not have a laboratory technician. In these schools, preparation and cleaning up of equipment had to be done by the science teacher. Hackling also indicated that the technician support in Australian schools was lower than the support provided in secondary schools in the UK.

The most common teaching resource that is used is the science textbook. The use of digital learning resource seems to be limited.

7. Issues and Recommendations

In the previous chapters, the ideal picture and the actual picture of Year 11 and 12 science have been outlined. The purpose of this final chapter is to identify the issues associated with the difference between these two pictures; then, having clarified these issues, realistic recommendations will be made. The expectation of these recommendations is that they will be used to more effectively bridge the gap between what we would wish to achieve in Year 11 and 12 science and what is presently happening.

7.1. Senior Science Curriculum

One of the dominant messages that emerged from the discussions and surveys of students and teachers is that the curriculum of the senior science subjects is far too content heavy, with an over-emphasis on preparing students for university science courses. The breadth of information in the Year 11 and 12 courses means that both students and teachers are continually under pressure to meet all the demanding requirements. The result is that there is little time to deal with ideas in depth. There is a sense that learning is superficial with an emphasis on memorisation rather than understanding.

Recommendation 1

The Australian Curriculum: Science courses of Biology, Chemistry, Earth and Environmental Science and Physics need to include a realistic amount of content for the time available. Furthermore, all the three strands of Science Understanding, Science as a Human Endeavour and Science Inquiry Skills need to be adequately covered in the content.

7.2. Students' Interest in Science

During the past two decades there has been a dramatic decrease in the number of students studying science in Year 12 from approximately 90% of all students to about 50%. There is no evidence this decrease has stopped. As a matter of some urgency this issue of student interest needs to be addressed. For a country like Australia more students need to be studying science at Year 11 and 12, not less.

The majority of students make their decisions on their subjects during the lower secondary years—Years 7 to 10. The quality and interest of science during these years needs to be improved. Initiatives that improve the quality of student learning and engagement should be encouraged and fostered. The program *Science by Doing* has shown that it can capture the interest of students and assist teachers to improve the quality of science engagement. It is important that this program is further developed and used to improve the quality of science learning in Years 7 to 10.

Recommendation 2

Attention needs to be directed to recapturing the interest of students in Years 7 to 10 science by supporting a program like *Science by Doing*.

7.3. Subject Selection by Students

During Year 10, students select their subjects for Year 11 and 12. In making these selections, students and parents need the best advice that is available for realistic decisions. Information received from both students and teachers indicate that in a number of cases the quality of this advice was questionable. Some students, including interested and able students, were actively discouraged from selecting science courses because of the perception that science subjects were difficult and time demanding.

It would be appropriate for a set of guidelines to be established for teachers and career advisors that would assist in providing quality advice to students. An organisation like the Australian Science Teachers Association could assist in developing such guidelines and sharing them with the profession.

Recommendation 3

A set of guidelines be developed to provide quality advice to Year 10 students considering selecting Year 11 and 12 science subjects.

7.4. Professional Learning for Teachers

As a generalisation, the pedagogy in senior science courses is very didactic. There is an emphasis on a 'chalk and talk' approach with an expectation that students will memorise significant amounts of science information. This approach has a strong summative assessment dimension.

In part, the transmission model of teaching is encouraged by the content heavy nature of the curriculum. With an anticipated revision of the new national Year 11 and 12 science curricula there is a need to emphasise a more inquiry-based approach to teaching. Teachers also need to be more creative in ways by which the outside world can be brought into the classroom.

Science is also a subject that is ever changing, with significant developments in a range of areas. Teachers need assistance to keep up with these developments.

Recommendation 4

Provide more professional learning opportunities for senior science teachers to expand their teaching skills including the latest scientific developments.

7.5. Supporting teachers

Teachers need time to effectively plan, teach and assess their courses. The present situation is that many teachers are short of time. While the new national curriculum subjects hopefully will provide the basis by which this situation can be improved, schools need to reflect on how the available time can be used more efficiently to improve student learning. Such reflection may result in more creative solutions to the use of time.

Teachers could be assisted in their teaching by the availability of quality curriculum resources, especially those that use new digital technologies.

Recommendation 5

Develop a suite of digital curriculum resources for the new national curriculum subjects that will assist teachers.

Recommendation 6

Increase the number of paraprofessionals, especially laboratory technicians, to support teachers.

7.6. Open Investigations

During the focus group sessions for students and teachers it became obvious that the large scale student investigation assessment activity occurring in some states is causing much anxiety for both students and teachers. There was sufficient anxiety to question whether the investigation activity is accomplishing the outcomes that were intended. Science education research would reinforce the value of student inquiry and investigations but it would appear there is a need to examine the ways these large scale investigations are being implemented.

Recommendation 7

Relevant boards of study need to evaluate the value, impact and implementation of large scale student investigation assessment activities.

7.7. Supply and Demand of Teachers

The available evidence suggests that generally senior science subjects are taught by experienced, well-qualified teachers. While some classes are taught by inexperienced out-of-field teachers, this is more the exception. As other studies (Goodrum *et al*, 2001; Goodrum and Rennie, 2007) have indicated, this is not the case in lower secondary science, where there are concerns about the shortage of qualified science teachers. It is possible in future that the shortage of science teachers will have an impact on the availability of senior science teachers. For that reason, there is value in revising some of the previous recommendations about addressing this shortage. In particular, the following previous recommendation is highlighted.

Recommendation 8

Re-examine the various pathways by which people may train (or retrain) to become teachers. The intention should be to increase options by removing barriers while maintaining quality. In particular, employing authorities should be encouraged to acknowledge the relevant skills and knowledge that new teachers bring with them from previous work experience in determining salaries (Goodrum and Rennie, 2007, p24).

8. Conclusion

While the report clearly identifies the impact of an overcrowded and abstract curriculum in Year 11 and 12 science courses, it also challenges us to consider what is the purpose of science learning during these senior years of secondary education. There is a strong prevailing view that the senior science subjects, especially biology, chemistry and physics, are preparation for university. Furthermore, the reason for studying these subjects, that some consider elitist, is to maximise a student's final university entrance score. This score provides the basis for course and university selection.

The question the report poses is 'Are we as a nation content that only half our senior secondary students are studying science?' If we are, then the years F to 10 and especially the compulsory high school years become critical in developing the scientific literacy of our students.

The lower secondary years 7 to 10 are also important in terms of generating interest in science. The decrease in the number of students studying senior science is a reflection of our failure to engage students in science in lower secondary. For this reason a program like *Science by Doing* becomes very important in addressing this issue.

For a country that believes its future prosperity is based on innovation and a skilled workforce this question needs to be addressed.

If one assumes that change needs to occur then how can this be done? The research outlined in this study clearly shows teachers are the key to educational improvement. While new teachers entering the system will assist, the real momentum for change will come from those experienced teachers already in the system. For this reason an extensive professional learning effort is required to help teachers work together with relevant quality resources to bring about the change that is needed.

To bring about this change there is a need for political leadership and financial support. With this leadership and funding, positive change will occur.

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Appendix 1: Information sheet for schools

<First name> <Surname>
<School name> <Campus>
<Address1>
<Address 2>
<Suburb> <State> <Postcode>

16 September 2011

Dear <First name>,

The Status and Quality of Year 11 and 12 Science in Australian Schools

The office of the Australian Chief Scientist has commissioned the Australian Academy of Science to conduct a review of Year 11 and 12 science in Australian schools. Your school has been randomly selected to gather information for that study. We seek your permission to do so.

It is our intention to speak with your Head of Science to determine the most efficient and least disruptive way to gather this information.

In 2000 an extensive study was undertaken for the Australian Government by a team with myself as principal researcher. A copy of the report is found at:

http://www.dest.gov.au/sectors/school_education/publications_resources/profiles/status_and_quality_of_science_schools.htm

That report has had a significant impact on subsequent education policy. This study focuses only on Year 11 and 12 science and is expected also to have an impact. Further details about the study are attached to this letter.

In anticipation of your support,

Yours sincerely,

Denis Goodrum

Professor Emeritus
Principal Researcher

<First name> <Surname>
<School name>
<Address1>, <Address2>
<Suburb> <State> <Postcode>

15 September 2011

Dear <First name>,

The office of the Australian Chief Scientist has commissioned the Australian Academy of Science to conduct a review of Year 11 and 12 science in Australian schools. Your school has been randomly selected for that study. A separate letter has been forwarded to your Principal.

Relevant information will be gathered through the completion of a simple student questionnaire. There are different questionnaires for Year 11 and 12 science and non-science students. Information about the questionnaires is included on a separate sheet.

Further details about the study are included in this letter. It is our intention to contact you via phone in a few days to discuss any questions you may have about the study.

In anticipation of your support,

Yours sincerely,

Denis Goodrum

Professor Emeritus
Principal Researcher

Appendix 2: Consent form

CONSENT FORM

The Status and Quality of Year 11 and 12 Science in Australian Schools

The office of the Australian Chief Scientist has commissioned the Australian Academy of Science to conduct a review of Year 11 and 12 Science in Australian schools. The school that your son or daughter attends has been randomly selected to gather information for that study. The research team seeks permission for your son or daughter to participate in the study. Participation will involve completing a short questionnaire or a focus group discussion. All information gathered will be done so anonymously with no student, school or jurisdiction identified in the final report.

In 2000 a similar but more extensive study was undertaken for the Australian Government by a team with myself as principal researcher. A copy of the report is found at:

http://www.dest.gov.au/sectors/school_education/publications_resources/profiles/status_and_quality_of_science_schools.htm

That report has had a significant impact on subsequent education policy. This study focuses only on Year 11 and 12 Science and is expected also to have an impact. Further details about the study are found at

http://www.science.org.au/sciencebydoing/research-evaluation/year11-12study.html

If you are comfortable with your son or daughter participating in this research would you please sign the consent form below.

In anticipation of your support, thank you

Yours sincerely

Denis Goodrum

Professor Emeritus and Principal Researcher

I give consent for my son or daughter

____

to participate in the research study as outlined above.

Signed____

Name____

Date_______________________

Appendix 3: Student Questionnaires

3.1 Science Student Questionnaire

Year 11 & 12 SECONDARY SCHOOL SCIENCE QUESTIONNAIRE
(For students studying science this year)

We are interested in what you think about science lessons at school.
On the following pages are some questions. There are no right or wrong answers, we are asking for your personal opinion. Please answer these questions as honestly as you can.

Background Information

(a) I am in Year 11 12 (Circle which year)

(b) I am Male Female (Circle one)

(c) List the subjects you are doing this year:

(d) Why did you choose the science subjects? (Please write your answer in the space provided.)

(e) When and how did you become interested in science?

The next pages of questions ask how often certain things happen during your science lessons at school, or how often certain things are true.

There are no right or wrong answers. Please read each sentence carefully then say what you think by putting a circle around the number that is right for you.

In my science class	Never	Once a term or less	About once a month	About once a week	Nearly every lesson
1. I copy notes the teacher gives me.	1	2	3	4	5
2. I work out explanations in science with friends or on my own.	1	2	3	4	5
3. I have opportunities to explain my ideas.	1	2	3	4	5
4. I read a science textbook.	1	2	3	4	5
5. I watch the teacher do an experiment	1	2	3	4	5
In my science class					
6. we do experiments by following instructions.	1	2	3	4	5
7. we plan and do our own experiments.	1	2	3	4	5
8. we have class discussions.	1	2	3	4	5
9. we learn about scientists and what they do.	1	2	3	4	5
10. we do our work in groups.	1	2	3	4	5

In science we	Never	Once a term or less	About once a month	About once a week	Nearly every lesson
11. do practical work outside in the schoolyard, the beach or in the bush.	1	2	3	4	5
12. have excursions to the zoo, museum, science centre or places like that.	1	2	3	4	5
13. have visiting speakers who talk to us about science.	1	2	3	4	5
14. use computers to do our science work.	1	2	3	4	5
15. look for information on the internet at school.	1	2	3	4	5
16. investigate to see if our ideas are right.	1	2	3	4	5
My science teacher					
17. tells me how to improve my work.	1	2	3	4	5
18. gives us quizzes that we mark to see how we are going.	1	2	3	4	5
19. talks to me about how I am getting on in science.	1	2	3	4	5
20. lets us choose our own topics to investigate.	1	2	3	4	5

Science	Almost never	Some-times	Often	Very often	Almost always
21. is relevant to my future.	1	2	3	4	5
22. is useful in everyday life.	1	2	3	4	5
23. helps me make decisions about my health.	1	2	3	4	5
24. helps me understand environmental issues.	1	2	3	4	5
25. is important to Australia's future.	1	2	3	4	5

In science we need to be able to	Almost never	Some-times	Often	Very often	Almost always
26. think and ask questions.	1	2	3	4	5
27. remember lots of facts.	1	2	3	4	5
28. understand and explain science facts.	1	2	3	4	5
29. recognise the science in the world around us.	1	2	3	4	5
During science lessons					
30. I get excited about what we do.	1	2	3	4	5
31. we have enough time to think about what we are doing.	1	2	3	4	5
32. I am curious about the science we do.	1	2	3	4	5
33. I am bored.	1	2	3	4	5
34. I don't understand the science we do.	1	2	3	4	5
35. I find science too easy.	1	2	3	4	5
36. I find science challenging.	1	2	3	4	5
37. I think science is too hard.	1	2	3	4	5

Please write answers to these questions in the spaces provided.

What are the things you really like about science in your class?

What are the things you don't like about science in your class?

How could your science class be improved **so that you could learn more**?

What do you intend to do after Year 12 regards work or study?

Thank you for your help

3.2 Non-science Student Questionnaire

Year 11 & 12 SECONDARY SCHOOL SCIENCE QUESTIONNAIRE
(For students NOT studying science this year)

We are interested in why you decided not to study science this year.

Background Information

(a) I am in Year 11 12 (Circle which year)

(b) I am Male Female (Circle one)

(c) List the subjects you are doing this year. (Please write your answer in the space provided.)

Questions

(d) Why did you choose not to study science? (Please write your answer in the space provided.)

(e) What do you intend to do after Year 12 regards work or study?

Please read the following sentences carefully then say what you think by putting a circle around the number that is right for you.

Science	Almost never	Some-times	Often	Very often	Almost always
1. **is relevant to my future.**	**1**	**2**	**3**	**4**	**5**
2. **is useful in everyday life.**	**1**	**2**	**3**	**4**	**5**
3. **helps me make decisions about my health.**	**1**	**2**	**3**	**4**	**5**
4. **helps me understand environmental issues.**	**1**	**2**	**3**	**4**	**5**
5. **is important to Australia's future.**	**1**	**2**	**3**	**4**	**5**

Thank you for your help

Appendix 4: Telephone Survey Response Sheet

State/Territory:	Sector: State/Catholic/Independent		Male/Female

Do you teach year 11 or 12 science? Yes/No

Question	Response
1. What year 11 or 12 science subjects do you teach?	
2. What approximate percentage of students study science in Year 11 & 12?	
3. If you have a science qualification what is it? What is your major?	
4. What is the most popular year 11/12 science subject?	
5. Why?	
6. What is the typical approach to teaching science in your school? (If a visitor went into a classroom and observed a science lesson what would they see?)	
7. What are the typical assessment methods you use in year 11/12 science?	
8. How is assessment reported to parents e.g. comments, grade, percentage levels, portfolios, outcome levels?	
9. What is the most important factor that inhibits or restricts your teaching of science? (limit to one factor)	
10. What is the single most important way that Year 11/12 science teaching could be improved in your school?	

Appendix 5: Approval Letters from Education Departments

Government of South Australia

Department of Education and Children's Services

Policy and Communications
Education Centre
Level 8//31 Flinders Street
Adelaide 5000
South Australia

Tel: 8226 0119
Fax: 8226 7839

DECS CS/11/102-2.4

26 August 2011

Professor Denis Goodrum
GPO Box 783
Australian Academy of Science
CANBERRA ACT 2601

Dear Professor Goodrum

Your project titled *"The Status and Quality of Year 11 and 12 Science in Australian Schools"* has been reviewed by a senior DECS consultant with respect to protection from harm, informed consent, confidentiality and suitability of arrangements. Subsequently, I am pleased to advise you that after careful consideration, your project has been **approved**.

The DECS Reviewer of this project is Ms Jan Brooks, Curriculum Manager – Science, Teaching and Learning Services, DECS.

If you wish to discuss further, with Ms Jan Brooks any aspect of the review process please feel free to contact her on Ph: 8226 4310.

Also, please contact Mr Jeffrey Stotter, Research Coordinator on (08) 8226 0119 for any other matters you may wish to discuss regarding the general review/approval process.

Please supply the department with an electronic copy of the final report which will be circulated to interested staff and then made available to DECS educators for future reference.

I wish you well with your project.

Leace C. Mincham
for

Ben Temperly
HEAD OF POLICY AND COMMUNICATIONS

Education and Training

File Ref: 2011/00468-7

Mr Denis Goodrum
Australian Academy of Science
Gordon St
CANBERRA ACT 2600

APPROVAL OF RESEARCH

Dear Mr Goodrum

Thank you for your application to conduct the proposed research titled *The Status and quality of year 11 and 12 Science in Australia Schools.* I am pleased to inform you that the Education and Training Directorate (the Directorate) has approved your research.

Please note the following conditions regarding your proposed research:

- research must be concluded by 30 June 2012. Extension beyond this date will be granted on providing evidence of public liability insurance
- any changes in the methodology, scope and timeframe of the project requires the Directorate's approval
- within one month of completing your research, you are required to forward a copy of your research (paper/report/thesis) either electronically to det.research@act.gov.au or by mail to the following address:

  Senior Manager
  Planning and Performance
  Education and Training Directorate
  ACT Government
  GPO Box 158
  CANBERRA ACT 2601

The Directorate approves research in the following schools; [redacted]. You may now directly approach the principals of these schools with a copy of this approval letter for permission to carry out your research. It will be at the discretion of the principal as to whether your research can proceed at their site.

A person entering a school to conduct research is a *visitor* to the school and must comply with the *Visitors in Schools* policy available at http://www.det.act.gov.au/publications_and_policies/policy_a-z

If the principal assesses that the nature of the activity and/or the type of contact may place students at risk, the researcher will be required to undergo screening. The responsibility and associated costs of screening will be met by the researcher or sponsoring organisation.

GPO Box 158, Canberra ACT 2601 | 220 Northbourne Avenue, Braddon ACT 2612
ABN 71 506 957 312 Telephone 02 6207 5111 | Facsimile 02 6205 9333 | Web www.det.act.gov.au

Any information that you obtain as part of research or data collection must be treated in accordance with the requirements of the *Privacy Act 1988*.

If you require any assistance please contact Atem Garang on (02) 62071032 or at Atem.Garang@act.gov.au

Best wishes with your research.

Yours sincerely

Leo Bator
Manager

16 September 2011

NSW GOVERNMENT | **Education & Communities**

Prof Denis Goodrum
GPO Box 783
CANBERRA ACT 2601

DOC 11/184658

Dear Prof Goodrum SERAP Number **2011144**

I refer to your application to conduct a research project in New South Wales government schools entitled *The status and quality of Year 11 and 12 Science in Australian Schools.* I am pleased to inform you that your application has been approved. You may now contact the Principals of the nominated schools to seek their participation. **You should include a copy of this letter with the documents you send to schools.**

This approval will remain valid until 2 September 2012.

The following researchers or research assistants have fulfilled the Working with Children screening requirements to interact with or observe children for the purposes of this research for the period indicated:

Name	**Approval expires**
Ms Joanna Elizabeth Abbs	07-09-12
Ms Amelia Margaret Druhan	07-09-12
Prof Denis Goodrum	07-09-12

I draw your attention to the following requirements for all researchers in New South Wales government schools:

- School Principals have the right to withdraw the school from the study at any time. The approval of the Principal for the specific method of gathering information for the school must also be sought.
- The privacy of the school and the students is to be protected.
- The participation of teachers and students must be voluntary and must be at the school's convenience.
- Any proposal to publish the outcomes of the study should be discussed with the Research Approvals Officer before publication proceeds.

When your study is completed please forward your report marked to Manager, Schooling Research, Department of Education and Training, Locked Bag 53, Darlinghurst, NSW 2010.

Yours sincerely

Dr Max Smith
Senior Manager
Student Engagement and Program Evaluation
6 September 2011

Student Engagement and Program Evaluation Bureau
NSW Department of Education and Communities
Level 3, 1 Oxford Street, Darlinghurst NSW 2010 – Locked Bag 53, Darlinghurst NSW 1300
Telephone: 02 9244 5619– Fax: 02 9266 8233 – Email: serap@det.nsw.edu.au