CHOOSING SCIENCE

Understanding the declines in senior high school science enrolments

Terry Lyons & Frances Quinn

Australian Science Teachers Association

Australian Government

SiMERR

une University of New England

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Executive summary

Overview of the *Choosing Science* study

The last two decades have seen significant declines in the proportions of high school students choosing senior physics, chemistry and biology courses in Australia. Concern has been expressed in many quarters about the implications of these declines for the supply of future scientists, the quality of the scientific endeavour in Australia and the levels of scientific literacy of its citizens. The *Choosing Science* study represents a large-scale national attempt to understand the influences on Year 10 students' decisions about taking science subjects in Year 11.

The study was undertaken in two phases. In Phase One, 589 secondary school science teachers were surveyed to identify their perceptions about the enrolment declines and students' deliberations. Findings from this survey informed Phase Two, a survey of 3759 Year 10 students who had recently chosen their subjects for Year 11.

Key findings

The study found that declines in the proportions of students taking physics, chemistry and biology are part of a broader phenomenon which has seen similar falls in many traditional subject areas, including economics, geography, history and advanced mathematics. This realisation, along with evidence from the teacher and student surveys, led to the conclusion that declines in science enrolments are *most likely* due to an interrelated set of factors centred on the changing context of subject choice for senior high school. The principal factor appears to be students' responses to the greater array of options available in Year 11, resulting in proportionally lower enrolments in many long-standing subjects. The context of greater choice has also heightened the influence of three contributing factors more closely associated with science education:

- the difficulty many students have in picturing themselves as scientists;
- the decrease in the utility value of key science subjects relative to their difficulty; and
- the failure of school science to engage a wider range of students.

Evidence from the study indicates that the following factors are *unlikely* to have contributed significantly to falling enrolments:

- declines in the level of interest in science among today's young people;
- students' perceptions that science careers attract relatively low pay;
- students' perceptions that it is difficult to find a job in science;
- students' experiences of primary school science.

These conclusions are discussed in detail in Chapter 8. A summary of the findings upon which they are based follows the list of recommendations.

Recommendations

Recommendation 1: That education authorities, science organisations and other stakeholders seeking to formulate policy to address declines in science enrolments take into consideration the findings of this study concerning the relative contributions of various factors to these declines.

There has been a great deal of speculation about the underlying causes of long term declines in physics, chemistry and biology enrolments. Increasing levels of concern have prompted education authorities, universities and science organisations to initiate a variety of interventions aimed at reversing these declines. The first step to developing effective policy to increase enrolments is to appreciate the complexity of interrelationships between curriculum, societal, school and student factors associated with the declines. Because the declines have been strongly influenced by students' responses to systemic curriculum changes, it cannot be expected that interventions targeting teacher education, science syllabus development or better promotion of science courses and careers will result in these subjects attaining the same levels of curriculum market share they realised in the early 1990s.

The more competitive curriculum environment makes it critical that steps are taken to ensure school science is more engaging, inclusive and valued by students. The study identified several areas of science education that should be addressed in this respect.

Recommendation 2: That the Australian Curriculum, Assessment and Reporting Authority (ACARA), federal, state and territory education authorities and others relevant stakeholders ensure the new National Science Curriculum

reflects teachers' and students' recommendations for increasing enrolments by making school science learning experiences more interesting, practical and personally relevant.

This recommendation is supported by the finding that 55% of students choosing no Year 11 science did so because they found junior high school science to be uninteresting. It is also consistent with science teachers' principal recommendation that the most effective strategy to encourage students to enrol in senior science is to ensure junior science classes are relevant, interesting and enjoyable. In particular, teachers' comments about the importance of contextualised learning and students' recommendations about more experimental/practical experiences should be taken into consideration.

Recommendation 3: That federal, state and territory education authorities, professional teacher associations and science organisations work together to develop adequately funded, sustainable and coordinated strategies to improve links between school science and scientists in university and industry settings. The strategies should have a particular focus on authentic, research-based science experiences both inside and outside the classroom and creating greater awareness among Year 10 students of the variety and scope of science-related careers.

Around two thirds of Year 10 students choosing no senior science made this decision principally because they could not picture themselves as scientists. Further, only 35% of students considered that school science had opened their eyes to new and exciting jobs. The science teachers believed that students lack information about potential career paths, and strongly recommended the establishment of links to industry. In addressing this, existing programs such as *Scientists in Schools* or similar should be expanded, and measurable outcomes established. One possibility for exploration is that students who perform well in and enjoy science be given opportunities to proceed into alternative entry or accelerated higher education schemes.

Recommendation 4: That education authorities and universities ensure that the value of academically challenging subjects such as physics and chemistry (and indeed difficult non-science subjects) is adequately recognised in calculations of university entry scores/rankings and entry requirements across Australia.

Around 67% of science teachers believe that declines in science are due to students' tendency to choose less academically challenging subjects from the broad curriculum available. Implicit in this view is the belief that students weigh up the anticipated benefits and costs of taking subjects. In the context of the 'curriculum marketplace', one salient cost of taking physics and chemistry is their difficulty relative to many other subjects. Adequate and explicit recognition of this difficulty in university entrance calculations and requirements would go some way towards making these science subjects more attractive to students.

Recommendation 5: That science teachers should encourage girls to have greater confidence in their science learning and ability to achieve. Education authorities, professional associations and science organisations should continue working towards removing the barriers to participation by girls in some areas of science, and encourage initiatives to educate students about the range of opportunities available to women in science careers.

Because of perceptions that physics and chemistry are relatively difficult subjects, self-efficacy becomes an important consideration in students' decisions about these subjects. This study confirmed that Year 10 girls tend to have lower levels of self-efficacy than do boys and are therefore more sensitive to anticipated difficulty. Girls choosing no science were also significantly more likely than boys to attribute this decision to being unable to picture themselves as scientists.

Recommendation 6: That federal, state and territory education authorities and other stakeholders should carefully consider which stage of schooling represents the most cost-effective target for strategies aimed at improving and sustaining senior high school science enrolments.

Around 80% of Year 10 students believed their most recent experiences (Years 9 & 10) had the greatest influence on their decisions about taking senior science classes. Fewer than 8% of students believed their decisions were most affected by primary school experiences, and among those choosing science this percentage was even smaller. While acknowledging that students may not remember earlier influences or be aware of the cumulative effects of their experiences, the findings nevertheless challenge assumptions that targeting primary science education will result in more students choosing science in Year 11 (see also Recommendation 9).

Recommendation 7: That professional science teacher associations take steps to ensure their members are made more aware of the strong influence teachers have on students' decisions about choosing science.

The study found that while science teachers consider themselves to have less influence on students' decisions than peers and parents, Year 10 students believe teachers to be the most influential agents of all. This was particularly the case among students who chose Year 11 science. Science teachers need to be made aware that students are influenced by their attitudes and advice concerning Year 11 science subjects and careers paths.

Conclusions from the study also revealed a need to undertake further research in three areas:

Recommendation 8: Education authorities and other stakeholders should initiate further research to investigate why students in rural schools have less positive attitudes to school science than their city peers.

The study found that students in rural areas had significantly less positive attitudes towards science than those in larger population centres. They were also less inclined than city students to enjoy science more than other subjects. As these results are not represented elsewhere in the science education literature and no obvious explanation suggests itself, further research is required.

Recommendation 9: Education authorities and other stakeholders should initiate further research to investigate how school type (single sex or coeducational) affects Year 10 students' perceptions of their abilities in science.

The study found that boys in single sex schools tend to rate their abilities in science significantly higher than do boys in coeducational schools. However, a similar contrast was not found among girls in these school types. This curious and perhaps counterintuitive finding represents an avenue for further research.

Recommendation 10: Education authorities and other stakeholders should initiate further research to determine the influence of students' attitudes to science on their enrolment intentions, and in particular to clarify at what point students' attitudes are most salient to their decisions.

Students' in this study indicated that they enjoyed learning science more in Years 9 and 10 than in early secondary school, which they enjoyed more than in primary school. This finding is at variance with conventional thinking about developments in students' attitudes as they progress from primary to middle secondary years. The different results may be due to the different research methodologies employed. Given the influence of research findings on policy formation it is particularly important that this issue is further investigated and clarified.

Summary of findings from the Science Teacher Survey

T1. What do science teachers see as the key influences contributing to declines in science enrolments?

Science teachers tend to believe that enrolment declines have been due principally to students' responses to the expanded range of subjects on offer in Year 11, including an increasing preference for less academically demanding courses. To a lesser extent teachers also believe that students today are less interested in science, lack information about science careers, and are put off by perceptions that such careers are poorly paid. Specifically, the study found that:

- 67% of teachers considered the declines to be strongly influenced by students' tendencies to choose less academically demanding courses;
- 64% believed that students' reluctance to persevere with the rigorous tasks associated with science study have been very influential in the declines;
- 50% attributed the enrolment declines to a decline in the level of interest in science by today's young people;
- 47% thought that the declines are due to students' lack of knowledge about science careers;
- 42% believed the declines to be strongly influenced by student perceptions that science careers are not well paid.

T2. Do teachers' perceptions vary significantly across states/territories, school sectors or locations?

The views of teachers were generally consistent regardless of state/territory, school sector or rural/urban location.

T3. Which sources of advice about science courses do teachers consider most influential in students' deliberations?

Teachers tend to believe subject advice from friends and peers is the most influential on students' decisions, followed by advice from older students or siblings. The advice of parents was seen as having less influence than advice from within students' own age group, though more influence than advice from science teachers. Career advisers were regarded by teachers as having the least influence on students' decisions. Overall, the teachers' beliefs about the relative influence of advice from significant others differed markedly from that of their students, who felt that science teachers were the most influential in helping them decide about taking science subjects (see S.15).

T4. What advice do teachers have for increasing enrolments in senior science courses?

Science teachers consider that more students will be encouraged to enrol in Year 11 courses if their junior science experiences are made more relevant, interesting and enjoyable. Suggested strategies to achieve this include greater exposure to context-based learning and increasing the amount of quality practical work. Teachers also feel that activities linking students with real scientists and science projects will provide greater motivation to continue with science study.

Summary of findings from the Year 10 Student Survey

Students' experiences of, and attitudes towards, school science

S1. What are Year 10 students' attitudes towards school science?

Year 10 students tend to be divided in terms of their enjoyment of and interest in science. While many enjoy school science, a significant number do not. The study found that:

- 45% of Year 10 students considered science lessons to be fun;
- About 44% considered science to be one of the most interesting school subjects;
- 36% looked forward to science lessons, though about 34% did not;
- around a third of students found science lessons boring;

- students in small rural or remote towns indicated they enjoyed science less than did those in larger centres.

S2. Do students like school science better than other school subjects?

As mentioned above, 44% of Year 10 students considered science to be one of the most interesting school subjects. Further, around a third liked it more than most other subjects. Girls were less inclined than boys to count science among their most enjoyable subjects. Students in small rural or remote schools were less inclined than those in larger centres to prefer science to their other subjects.

S3. At what stage of schooling do students most enjoy learning science?

Around 78% of students reported enjoying science more in secondary school than in primary school, and around 55% claimed they enjoyed it more during Years 9 and 10 than at other stages of their schooling.

S4. Do Year 10 students believe that school science helps them make sense of the world?

About 63% of students agreed that school science helped them make sense of the world, while about 16% did not agree. Boys were significantly more inclined than girls to agree with this statement.

S5. Does what students learn in science make them feel pessimistic (negative) about the future?

Only about 17% of students agreed that learning science made them feel pessimistic about the future, while 53% disagreed. The remaining 30% were unsure.

S6. Are students' perceptions of their academic ability in science associated with personal or school characteristics?

Around half the students rated their own academic ability in science above average compared to others in their Year 10 class. Girls tended to rate their abilities significantly lower than did boys. Boys in single sex schools tended to rate their abilities significantly higher than did boys in coeducational schools, however this difference was not evident in the case of girls.

S7. What would Year 10 students change about high school science to encourage more students to choose science in Year 11?

Year 10 students overwhelmingly recommended increasing the amount of practical/experimental work to encourage greater interest and participation. They also suggested teachers place much more emphasis on the relevance and applicability of science, rather than on the theory. Students saw issues of basic pedagogy and curriculum as being far more critical to enrolments than issues of resourcing such as better textbooks, laboratory and computers, which attracted relatively little comment.

S8. Have students' attitudes to science and science careers declined over the period of enrolment declines?

Choosing Science investigated whether students' attitudes to science and science careers had changed significantly since 1977 when science enrolments were proportionally much higher. Results from the comparison indicated that the attitudes of today's students towards science and scientists, and their level of enjoyment of school science, are not significantly different to those of students a generation ago. While scores on these measures were marginally lower for the contemporary sample, effect sizes indicate that the differences are unlikely to be educationally meaningful, particularly given the 30 year period separating the two studies.

With respect to students' interest in science careers, the comparison found no significant differences between the level of interest of today's students and those of students in 1977. Overall, these findings challenge assumptions that declines in science enrolments are due to more negative attitudes towards science or science careers among today's Year 10 students.

Students' decisions about choosing or not choosing science

S9. What reasons do students give for choosing senior science subjects?

Overall, students choosing Year 11 science subjects did so primarily because they believed the subjects would be interesting. The strategic benefit of taking science for university or careers was also widely endorsed, followed by self-efficacy in the subject. In particular, the study found:

- About 77% of students chose their science subject because they felt it would be interesting;
- 60% chose their science subject because they needed it for their university or career aspirations;
- Around 61% chose science because they had received good results;

- 57% agreed they chose senior science because they found junior science interesting.

S10. Do students' reasons for studying science vary across subject choice categories?

Students choosing physics, chemistry or biology were motivated to a similar extent by the anticipated interest of their chosen subject. Students taking physics or chemistry placed significantly greater weight on instrumental motivations relating to careers or university courses than did those taking biology or other science. Likewise, the physics and chemistry students were more motivated than others by the good marks they had achieved in science, and by the belief that 'scaling' in these subjects would improve their university entry score/ranking. Students choosing chemistry without physics were more motivated by experiences in junior science and good teachers than were students making other choices. Students choosing physics or chemistry were more inclined than others to attribute their decisions to the encouragement of teachers.

S11. What reasons do students give for not choosing senior science?

Students choosing no science subjects for Year 11 indicated a range of reasons for their decisions, the two most common of which related to their aspirations for the future. In particular, the survey found:

- Two out of three chose no science primarily because they could not picture themselves as scientists. This was the most commonly expressed reason, highlighting the significance of students' self-identity and images of scientists;
- 63% indicated that they didn't need science for university or a career;
- Around 55% chose no science subjects because they found junior school science uninteresting;
- About 50% decided against Year 11 science because they felt they were not good at science.

S12. Are students' enrolment decisions associated with their attitudes to and perceptions of science?

Of the 3759 respondents, 2851 had chosen to enrol in one or more Year 11 science subject, while 908 had chosen no science subjects. An analysis of the views of school science held by students making different enrolment decisions revealed the following:

- Students choosing physics and chemistry generally had more positive attitudes to school science and rated their academic ability in science higher than students making other choices;
- Students choosing physics and chemistry were much more inclined than others to believe that school science helped them make sense of the world;
- Students choosing no science were more inclined than physics, chemistry or biology students to agree that school science made them feel pessimistic about the future;
- Students choosing no science were far more likely than others to disagree that school science helped them make sense of the world;
- Students choosing no science tended to rate their academic ability in science much lower than other students;
- Students choosing biology or other sciences tended to rate their attitudes and perceptions and academic ability somewhere between those of students choosing physical science and those choosing no science.

S13. Is there an association between students' reasons for choosing or not choosing science and their sex, school type or school sector?

There were no meaningful significant differences across sex, school type or sector in terms of reasons for choosing science. There were however differences between boys and girls in their reasons for not choosing science. Girls were significantly more inclined than boys to attribute their decisions to low self-efficacy in science, to the anticipated difficulty of science subjects and to their inability to picture themselves as scientists.

S14. Which stage of schooling do students believe had the most influence on their decisions about taking senior science subjects?

Nearly 80% of students thought their most recent experiences (Years 9 and 10) had had the greatest effect on their decisions. Around 13% were influenced most by their Year 7 and 8 experiences, while less than 8% believed they were more influenced by their primary school experiences than their secondary school experiences. Those choosing no science tended to rate their primary school experiences as more influential on this decision than did those choosing science subjects.

S15. Which people do students consider the most influential in helping them make their decisions about choosing science?

Students considered science teachers to have been the greatest influence in helping them decide whether to take science courses in Year 11. This was especially true of students choosing science. The influence of teachers was rated higher than that of mothers and fathers, followed by close friends. Boys choosing science tended to attribute significantly more influence to their fathers than did girls choosing science, though among students choosing no science, fathers were considered to be only as influential as close friends, if not less so. Careers advisors, older students and siblings were considered to have had the least influence. Students choosing no science tended to rate the influence of all others on their decisions substantially lower than did those choosing science.

Students' ideas about scientists and science careers

S16. What are students' views about science-related university study and careers?

Students are generally positive about the availability of science careers and the salaries they attract. The study found that:

- about 50% of students agreed that it is fairly easy for a person with a science degree to gain employment as a scientist. Only 14% disagreed and the remaining students were unsure;
- 52% of students believed that science careers are well paid. A further 35% were unsure, while only 13% disagreed. This finding is at odds with the view of 45% of science teachers that declines in science enrolments have been strongly influenced by students' perceptions that these careers are not well paid;
- respondents were evenly split over the likelihood that they will choose a science-related university course once they leave school, with around 40% agreeing, 40% disagreeing and the remainder unsure;
- students choosing physics or chemistry were significantly more likely than those choosing other options to agree that they will probably enrol in a science related university course;

- while around 50% agreed that a being a scientist would be interesting, only 15% agreed that they would like to become scientists;
- Only about 8% of students agreed they would like to become science teachers, with around 72% disagreeing or strongly disagreeing with this prospect;
- Only about 35% of students agreed that school science had opened their eyes to new and exciting jobs.

S17. Do Year 10 students' intentions about science-related university study vary with Year 11 science subject choices and perceived ability?

Students choosing physics and/or chemistry for Year 11 were more likely than students in the other science categories to agree that they would choose university science, even when differences in perceived ability were taken into account. Students with higher self-rated ability were also more likely to agree that they would choose a university science course.

S18. Where do Year 10 students get their ideas about science careers?

In terms of where they obtained their knowledge about science careers, no single source stood out noticeably from others. About 45% of students agreed that their Year 10 teacher often discussed science careers with them, though 36% disagreed that this was the case. Fewer than 30% of students agreed that they obtained most of their ideas about science careers from their parents, the media or their careers advisors.

S19. How well do relative perceptions about careers, ability and enjoyment of school science predict students' intentions to study science at university?

Multiple regression analysis indicated that Year 10 students' aspirations about undertaking a science-related university course are related predominantly to three variables: enjoyment of school science relative to most other subjects; an awareness of new and exciting science related career paths and; to a lesser extent, a relatively high self-rating of academic ability in science. Despite students' general agreement that science jobs are both easy to get and well-paid, pragmatic concerns relating to remuneration and employment contributed relatively little to their intentions to undertake a science-related university course.

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Overview

Arguably the most challenging and persistent issue in science education over the last two decades has been the significant declines in the proportions of high school students choosing to study physics, chemistry and biology courses across Australia. Concern has been expressed in many quarters about the implications of this trend for the supply of future scientists, the health of scientific endeavour in Australia and the scientific literacy of its citizens.

Similar declines have been recognised in most other developed countries and the sheer number of significant policy documents produced around the world attests to the level of concern. The momentum built up by these reports and the extensive media coverage they have generated has led to a great deal of speculation not only about the nature and root causes of the declines, but about how best to respond. In such a climate there is a risk that policy initiatives to address declines may run ahead of research evidence. It is particularly important in light of the National Science Curriculum currently under development that reliable evidence about student responses to existing science curricula is available.

Concerns about dwindling science enrolments are often framed in the context of future demand for science, engineering and technology (SET) careers. However, in addition to supporting the nation's industrial and research enterprises science education seeks to achieve a broader social goal. Being part of a modern, technologically advancing democracy calls for a higher degree of scientific literacy than at any time in the past. Our national education policy has the explicit goal of improving the scientific and technological literacy of all Australians (DEST, 2003) - a goal unlikely to be achieved by producing fewer citizens who have an understanding of science beyond what they learned at age 15.

The *Choosing Science* study represents a large-scale national attempt to understand the influences on Year 10 students' decisions about taking science subjects in their final years. The study drew on the opinions of 589 science teachers and 3759 Year 10 students concerning a broad range of issues to construct a detailed picture of the deliberations and influences involved in these decisions. The project was a collaboration between the National Centre for Science, ICT and Mathematics Education for Rural and Regional Australia (SiMERR Australia) at the University of New England, and the Australian Science Teachers Association (ASTA).

The design of the study was grounded in an extensive body of Australian and international literature concerning students' attitudes to and engagement with school science. This chapter provides a brief overview of the most relevant research, identifying gaps in our current understanding and presenting the research questions addressed by each of the report chapters.

High school science enrolment trends in Australia

The downward trend in physics, chemistry and biology enrolments in Australia has been well documented (Ainley, Kos & Nicholas, 2008; Dekkers & DeLaeter, 2001; 1997). Figure 1.1 shows the most recent national statistics on Year 12 enrolments in science subjects (Ainley et al., 2008). The figure shows that the proportions of Year 12 students taking physics, chemistry, biology and geology have declined over the last three decades. According to Ainley et al. (2008), since 1976 the proportion taking physics almost halved from 28% to 15%, while the proportions choosing chemistry and biology decreased from 29% to 18% and from 55% to 25% respectively.

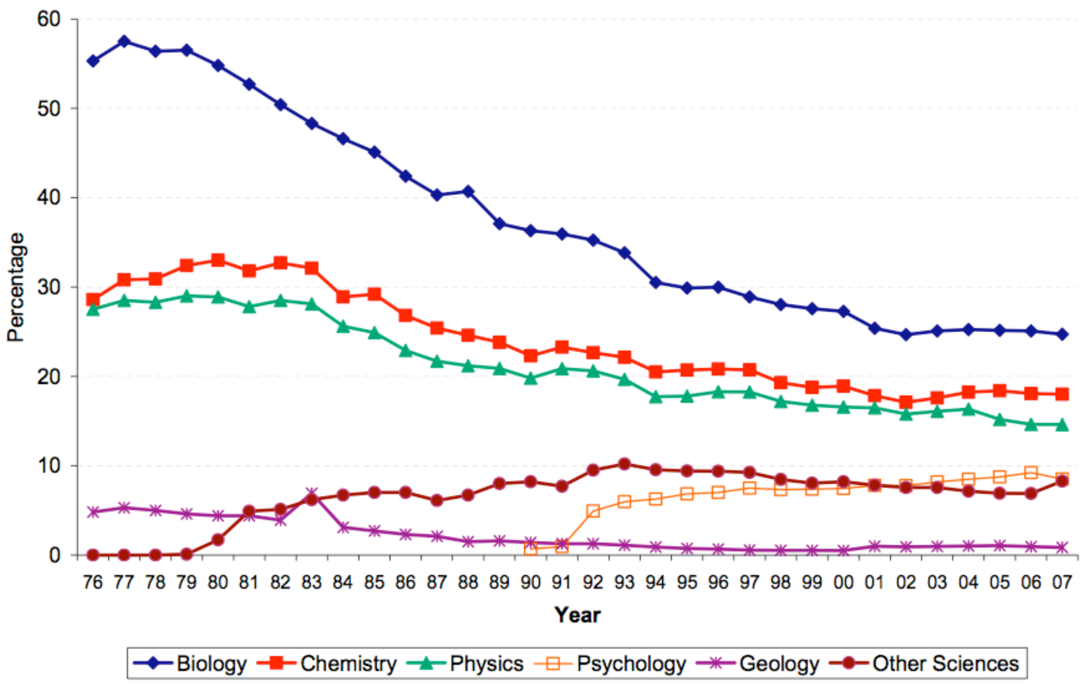

Figure 1.1: Year 12 science participation as a percentage of the total Year 12 cohort in Australian schools, 1976 to 2007 (Ainley, Kos & Nicholas, 2008)

Raw percentages do not tell the whole story, however, since the make up of Year 12 cohorts has changed substantially over this period. Whereas in 1982 only around 35% of students remained in school to Year 12, over the following decade the retention rate increased steadily, reaching 77% in 1992 (Ainley et al., 2008). Since then, retention rates have been relatively stable at around 75% (Australian Bureau of Statistics, 2009), so a more valid inference about trends can be made by examining enrolments over this period. According to Ainley et al. (2008), between 1992 and 2007 the proportions of Year 12 students choosing physics, chemistry and biology fell by 26%, 22% and 29% respectively.

Over the last three years some states/territories have reported increases in the raw numbers of students taking one or more of these subjects. However, when corresponding increases in the overall Year 12 cohorts are taken into consideration, the actual percentages of students choosing these sciences have in most cases either remained the same or declined.

University science enrolment trends in Australia

As might be expected, reports on participation in university science courses indicate a flow-on effect from school enrolment trends. According to Dobson (2007) the 1990s saw sharp declines in enrolments in the natural and physical sciences. He reported that while overall university enrolments more than doubled between 1989 and 2007, the actual number of students taking physics fell by around 19%, and the number taking chemistry fell by over 5%. While the number of students enrolling in biological sciences rose by 74%, this still constitutes a proportional decline. The Executive Director of the Australian Council of Deans of Science claims these trends represent a significant threat to a society 'participating in global economic transformation, whose competitiveness depends on riding huge waves of technological change, and whose survival depends on innovative responses' (Rice, 2007).

International science enrolment trends

Most developed countries appear to be experiencing similar enrolment trends to Australia at the high school or university level, or often both. Declines in student participation and interest in science throughout Europe have been the focus of major reports over the last five years, including *Europe Needs More Scientists* (European

Commission, 2004), *Science Education Now!* (European Commission, 2007), the *State of the Nation* (The Royal Society, 2008), and *Science Education in Europe: Critical Reflections* (Osborne & Dillon, 2008). Most recently, the European Round Table of Industrialists concluded that 'it is clear that Europe is facing very negative trends in the supply of human resources in MST (Maths, Science and Technology) … [particularly in] France, Germany, the Netherlands, Sweden and the United Kingdom' (ERT, 2009:9).

In England and Wales, Barmby, Kind and Jones (2008) reported a 41 per cent fall in the number of students going on to study Advanced-level physics between 1985 and 2006, while in Scotland enrolments in physics and chemistry declined by 15.1% and 8.4% respectively between 2001 and 2006 (Denholm, 2006). In Korea, the Chief Technology Officer of Samsung has raised concerns that the approximately 3:7 ratio of Humanities to SET enrolments in high schools in the 1980s has now been reversed (Ki-Tae, 2007). Reports from India indicate substantial declines in science enrolments at the school level (Garg & Gupta, 2003), while enrolments in postgraduate courses of natural science subjects declined from 26.6 per cent in 2000-01 to 11.5 per cent in 2003-04 (Varghese, 2006). There have, however, been reports of increases in the proportions of Indian students studying engineering courses (Shukla, 2005).

Other countries reporting declines in participation and interest in science include New Zealand (Hipkins & Bolstad, 2005), Canada (Bordt et al, 2001; Kennepohl, 2009); Israel (Trumper, 2006), Japan (Ogura, 2005) and Ireland (Jordan, 2009). In contrast to these trends, school and university science enrolments in the USA now appear to be on the increase, due in part to legislation requiring students to take more science and mathematics courses to qualify for a high school diploma (National Science Foundation, 2008).

Investigating science teachers' perspectives on enrolment declines

Science teachers are in a unique position to observe students' deliberations about Year 11 subjects, as well as enrolment trends more generally. Despite this, very few Australian studies have sought teachers' views on these matters. Phase One of the *Choosing Science* study therefore canvassed the opinions of science teachers about a number of plausible explanations for declining enrolments suggested by the literature, some of which are outlined below.

In a UK study, Woolnough (1993) asked head teachers from schools noted for their success in producing physics and engineering candidates why students decide for or against these careers. He found a belief among teachers that students were discouraged from pursuing a career in science by the low salaries and status of science careers – an opinion often heard in the Australian science community (Niland, 1998; Wood, 2004; Quinn & Godwin, 2002) and overseas (e.g. Lowell, Salzman, Bernstein & Henderson, 2009).

Woolnough also reported that the head teachers were more inclined to attribute students' decisions to in-school factors such as good teaching and careers advice, than to family background, parents or students' ability and interests. *Choosing Science* sought the views of Australian teachers concerning the relative influence of in-school and out-of-school factors, and in particular, which significant others had the greatest influence on students' decisions. Teachers' views were then compared with students' opinions collected in the second phase of the study.

Other reports have suggested that low interest in science may be due in part to the standard of science teaching in high schools. This impression was conveyed in the Australian Council of Deans of Science (ACDS) monograph *Who's Teaching Science?* (Harris, Jensz & Baldwin, 2005). The report found evidence that a significant proportion of science teachers are underqualified, and recommended upgrading teachers' discipline backgrounds and pedagogical skills. However, the study did not establish whether teacher quality and qualifications have actually declined over time and may therefore be related to falling enrolments. Further, suggestions that students are exposed to poor quality science teaching are inconsistent with the world-class performances of Australian 15 year olds in the OECD Programme for International Assessment (PISA) 2000, 2003 and 2006 studies.

A further area for investigation in *Choosing Science* was teachers' views on the impact of curriculum changes on enrolments. Some commentators (e.g. Larkin, 2005; Trounson, 2008; Derbyshire, 2003) have argued that the diversified curriculum has drawn students away from traditional science courses towards those considered less academically demanding. Other reports have suggested that the relative difficulty of physics and chemistry courses is not recognised sufficiently in the calculation of tertiary entrance scores (e.g. Mathematical Association of Western Australia, 2005), while there is also concern in some quarters that changes to science curricula have discouraged students from undertaking science courses (e.g. Fogarty, 2000; Kleinig, 2007). The views of Phase One science teachers from different states and territories were of particular interest in this regard.

Research questions relating to teacher perspectives

In view of the speculation about reasons for declining enrolments in secondary science, and the unique position of secondary science teachers to inform these discussions, Phase One of the *Choosing Science* study addressed four research questions:

T1. What do science teachers see as the key influences contributing to declines in science enrolments?

T2. Do teachers' perceptions vary significantly across states/territories, school sectors or locations?

T3. Which sources of advice about science courses do teachers consider most influential in students' deliberations?

T4. What advice do teachers have for increasing enrolments in senior science courses?

These questions are addressed in Chapter 3.

Investigating students' perceptions of and decisions about science

Phase Two of the study investigated three themes: Year 10 students' attitudes to and experiences of school science; their deliberations about taking Year 11 science subjects, and their ideas about scientists and science careers.

Students' experiences of, and attitudes towards, school science

Students' attitudes to school science have been the focus of considerable research, primarily in relation to achievement but more recently with regard to enrolment intentions. Attitudes in this study refer to a student's disposition to react with a certain degree of favourableness or unfavourableness towards his or her personal construction of school science (Ajzen, 1993). The disposition is generally reinforced by beliefs and feelings and may lead to particular behavioural intents (Ramsden, 1998).

Some Australian studies (e.g. Goodrum, Hackling & Rennie, 2001; Lyons, 2006a; Raison & Etheridge, 2006) found that many junior secondary students consider school science to be personally irrelevant, boring, and unnecessarily difficult. There is some evidence that this view is more prevalent among Australian students than their international peers. According to the 2006 PISA results, Australia was ranked 54th of 57 countries in terms of students' general interest in learning science, and 45th in terms of mean enjoyment of science (Thomson & De Bortoli, 2008).

Many reasons have been suggested for students' poor attitudes towards junior secondary science, including the 'chalk and talk' of transmissive pedagogy, a reduction in the amount of practical work, the personal irrelevance of science syllabus content, and an over-reliance on theory and textbooks (Tytler, 2007). Some studies have suggested that that students enter junior high school with a generally favourable attitude towards science, which becomes less positive over the next three or four years (Bennett & Hogarth, 2009; Gough et al., 1998; Speering & Rennie, 1996; Tytler, 2007). Nevertheless, other studies (e.g. Dix, 2005) have found that students' attitudes to schooling in general tend to decline during the junior and middle secondary school years. The *Choosing Science* study therefore sought to compare students' attitudes to science relative to other subjects.

Have students' attitudes to science changed?

With respect to enrolment declines, the key issue is not so much the nature of students' attitudes at any one point in time, but whether these attitudes have declined over time. The *Choosing Science* study therefore sought to compare the attitudes to contemporary students with those of students a generation ago when enrolments were proportionally much higher. Such a comparison involved finding reliable benchmark data on attitudes to science collected from an earlier Year 10 cohort. Fortunately the late 1970s and early 1980s saw groundbreaking research undertaken in this field by Fraser using the Test of Science Related Attitudes (TOSRA) instrument (Fraser, 1978). The TOSRA has been used in many studies in Australia and overseas and is still considered a valid and reliable instrument for gauging students' attitudes to science. The methodology involved in this comparison is detailed in Chapter 2.

The influence of primary school science experiences

The strengths and shortcomings of primary science teaching in Australia have been well described by Goodrum, Hackling and Rennie (2001), who concluded that many primary teachers lacked confidence in teaching science, adequate resources and opportunities for professional development. However, a recent claim that 'the skills crisis in science and engineering can be tracked, in part, to a lack of effective science education in primary schools' (Fittell, 2008) goes much further, implying an evidential link between students' primary school science experiences and declines in Year 11 science participation. A review of the literature found no substantive link to justify this claim. Indeed, the significant body of research cited above arguing that students' attitudes to science tend to decline *after* they leave primary school suggests the locus of the problem lies in junior high school. Nevertheless, in order to explore the influence of primary school science from a retrospective point of view, the *Choosing Science* student survey asked Year 10 students to reflect on their early experiences of school science and its influence on their enrolment decisions.

Gender, self-efficacy and science enrolments

Sex differences in enrolment patterns are a recognised feature of the science education landscape. Sex has been shown to be a strong predictor of science subject choice, with physics classes dominated by boys, biology classes by girls and chemistry classes fairly evenly balanced (Ainley et al, 2008; Fullarton, Walker, Ainley & Hillman, 2003). A number of explanations have been advanced to explain this pattern, including cognitive preferences (reviewed in Sjøberg & Imsen, 1988), the gendering of physics as male (Jones, Howe & Rua, 2000), the differential influence of peers (Astin & Astin, 1992) and parental expectations of sons and daughters (Eccles, 1989). One of the most promising explanations for the imbalance in physics enrolments concerns students' self-efficacy in science and the interaction of this with their conceptions of the relative difficulty of physics. The PISA 2006 results, for example, revealed that despite achieving similar scores for scientific literacy, Australian girls reported lower levels of self-efficacy and self-concept in science than boys (Thomson & De Bortoli, 2008). The *Choosing Science* study aimed to identify to what extent such differences were also associated with decisions about Year 11 science.

Research questions relating to students' attitudes and experiences

To further explore the gaps, contradictions and promising avenues in the literature, the first section of the student survey was designed to address the following questions:

S1. What are Year 10 students' attitudes towards school science?

S2. Do students like school science better than other school subjects?

S3. At what stage of schooling do students most enjoy learning science?

S4. Do Year 10 students think that school science helps them make sense of the world?

S5. Does what students learn in science make them feel pessimistic (negative) about the future?

S6. Are students' perceptions of their academic ability in science associated with personal or school characteristics?

S7. What would Year 10 students change about high school science to encourage more students to choose science in Year 11?

S8. Have students' attitudes to science and science careers declined over the period of enrolment declines?

Questions S1 to S7 are addressed in Chapter 4, while question S8 is addressed in Chapter 5.

Students' decisions about choosing or not choosing science

Researchers have generally approached the study of students' subject choices from one of two directions. Those taking a sociological perspective have tended to focus on patterns in enrolment data associated with students' demographic backgrounds. The Longitudinal Surveys of Australian Youth (LSAY) series, for example, has provided a thorough record of the demographic characteristics associated with enrolments in physics, chemistry and biology (e.g. Fullarton et al., 2003; Fullarton & Ainley, 2000). The LSAY studies found the choice of physics to be positively associated with being male, having parents with higher levels of education and socioeconomic status, having a language background other than English and attending a non-government school. The choice of biology was found to be positively associated with being female and attending a non-government school, and negatively associated with coming from a language background other than English. Other studies (e.g. Lyons, 2006b; Adamuti-Trache & Andres, 2008) found the choice of physics and chemistry to also be more closely associated than other choices with high levels of social capital and science-related cultural capital within families.

A second approach has been to focus more on students' rationales and decision-making processes. Studies taking this direction (e.g. Barnes, McInerney & Marsh, 2005; Raison & Etheridge, 2006; Hannover & Kessels, 2004; Haeusler & Kay, 1997) tend to view this process as one of reasoned action and individual motivation, albeit influenced by a student's sociocultural milieu.

Both approaches have been shown to produce valuable insights into students' motivations. However, as the demographic correlates with students' enrolments decisions are relatively well documented, the *Choosing Science* study focused more on students' rationales and individual perceptions.

Students' rationales for their decisions

Previous research indicates that students tend to explain their choices of physics and chemistry primarily in terms of strategic needs, such as university course requirements and careers aspirations. In contrast, those choosing biology tend to have more intrinsic reasons, such as interest and enjoyment (Ainley et al., 1994; Barnes et al., 2005). Those choosing no science subjects tend to do so because they "don't need to take science" (Lyons, 2003). The *Choosing Science* survey provided an opportunity to explore students' motivations further by inviting those making different decisions to differentiate between possible reasons suggested by the literature and comparing the degree to which they felt each was influential on their decisions.

Students' sources of advice about science subjects

In making their decisions about Year 11 subjects, students seek (or are offered) advice from a range of people, including careers advisors, teachers, parents, siblings and friends. It is important to identify from whom students seek advice, and to what extent this advice is influential on their decisions. The literature is unclear on both these questions. Most research in this area addresses students' subject choices in general rather than decisions about specific subjects, though the bulk of evidence suggests that students draw on different sources and use different strategies depending on the subject, their sex, age and the educational context (Haeusler and Kay, 1997).

Research questions relating to students' decisions

Reflections on the literature relating to students' science enrolment decisions generated seven questions, which are addressed in Chapter 6.

S9: What reasons do students give for choosing senior science subjects?

S10: Do students' reasons for choosing science vary across subject choice categories?

S11: What reasons do students give for not choosing senior science?

S12: Are students' enrolment decisions associated with their attitudes to and perceptions of science?

S13: Is there an association between students' reasons for choosing or not choosing science and their sex, school type or school sector?

S14. Which stage of schooling do students believe had the most influence on their decisions about taking senior science subjects?

S15: Which people do students consider the most influential in helping them make their decisions about choosing science?

Students' ideas about scientists and science careers

The third research theme concerns students' impressions of scientists, and their intentions regarding science-related university courses and careers. Students' images of scientists have been well documented (e.g. Chambers, 1983; Lederman, 1992; Matthews & Davies, 1999). Likewise, the proportions of Australian middle school students aspiring towards university science courses and careers are generally known. For example, 34% of Australian students participating in the 2006 PISA study agreed or strongly agreed that they would like to study science after secondary school, while 39% were inclined towards a career involving science (Thomson & De Bortoli, 2008). Boys reported higher expectations of future study or a career in science than did girls. Compared with students in other OECD countries, Australian students were less inclined to aspire to science careers.

As is the case with attitudes to school science, a one off measurement of students' career aspirations offers little insight into whether these may have declined in concert with enrolments. Fortunately, Fraser's 1977 TOSRA study also measured students' attitudes towards science careers, thereby providing a benchmark for comparison. As this investigation was undertaken as part of the TOSRA comparison, it is addressed by question S8 in Chapter 5.

Students' knowledge about science careers

The quantity and quality of career advice is of particular interest in science education research due to concerns that junior high school students have little understanding of the variety and nature of science-related careers (Cleaves, 2005; Speering & Rennie, 1996). Further, there are suggestions that some career advice provided by parents, teachers and career counsellors may even act to discourage participation in SET study (DEST, 2006).

As noted previously, some commentators have argued that students are discouraged from taking science subjects by perceptions of relatively low salaries for scientists. As there has been no research into the prevalence of this view among students deliberating about subject and career options, the *Choosing Science* study asked students for their opinions about anticipated remuneration.

Research questions relating to science careers and future intentions

To further understand Year 10 students' ideas and aspirations concerning science careers, the *Choosing Science* study posed four questions, which are addressed in Chapter 7:

S16. What are students' views about science-related university study and careers?

S17. Do Year 10 students' intentions about science-related university study vary with Year 11 science subject choices and perceived ability?

S18. Where do Year 10 students get their ideas about science careers?

S19. How well do relative perceptions about careers, ability and enjoyment of school science predict students' intentions to study science at university?

Chapter 2 : Research Design

Introduction

The *Choosing Science* study was conducted in two phases. In Phase One, 589 secondary school science teachers were surveyed to identify their perceptions about the enrolment declines and students' deliberation processes. Findings from this survey informed Phase Two, a survey of 3759 Year 10 students who had recently chosen their subjects for Year 11. This design allowed exploration of the perceptions within of each group, and comparisons to be drawn between groups.

This chapter describes the research methodology used in the two phases. For each phase, the study sample details are provided, together with a discussion of the survey design and coding procedures. The full sets of survey items are available as Appendices 1 and 2. The chapter also outlines the analytical processes used and describes how figures and tables should be interpreted.

Phase One: Science Teacher Survey

The science teacher sample

About 2000 secondary science teachers across Australia were invited to complete the online Science Teacher Survey. Invitations to participate were distributed principally through the Australian Science Teachers Association (ASTA). Responses were received from 611 teachers, representing a response rate of around 30%. Cleaning of data resulted in a final sample of 589.

Table 2.1 provides a description of respondents by state/territory, school type, sector, location and teaching experience. As shown in Table 2.1, most of the responding teachers were from Queensland, South Australia, Victoria and New South Wales. Relative to the numbers of secondary schools in each state/territory there was a higher than expected response rate from Queensland and South Australia and a lower than expected response rate from New South Wales (Australian Bureau of Statistics [ABS], 2008).

Table 2.1: Breakdown of teacher respondents by state, school sector, location and experience variables.

		Count	*% of total*
State/ Territory	ACT	16	*2.7*
	NSW	97	*16.5*
	NT	10	*1.7*
	QLD	146	*24.8*
	SA	133	*22.6*
	TAS	24	*4.1*
	VIC	117	*19.9*
	WA	46	*7.8*
Sector	Government	330	*56.0*
	Catholic systemic	83	*14.1*
	Independent	176	*29.9*
Location	Capital city	305	*51.8*
	Large non-capital city [a]	95	*16.1*
	Rural city or large rural town [b]	87	*14.8*
	Small rural or remote town [c]	102	*17.3*
Years of teaching experience	less than 5 years	98	*16.6*
	between 5 and 10 yrs	101	*17.1*
	between 10 and 15 yrs	71	*12.1*
	more than 15 yrs	319	*54.2*
	Total	**589**	***100***

[a] Population > 25 000; [b] Population between 10 000 and 25 000; [c] Population < 10 000

About 56% of respondents were from government schools, 14% from Catholic systemic schools and just under 30% from Independent schools. Sector representation within the sample was consistent with representation among Australian secondary schools more generally, that is: 57% government; 16% Catholic systemic; and 27% Independent (ABS, 2008).

Just over half the teachers taught in capital cities, with around a third coming from rural or remote areas. In terms of experience, about 16% of respondents had taught for less than five years, while more than half had been teaching for over 15 years.

Teacher Survey Instrument design

The survey was constructed as a web-based questionnaire consisting of four sections.

Section 1. About you and your school

This section collected data on respondent and school characteristics such as school type, school sector, state/territory, geographic location and length of teaching experience. These independent variables were used to determine whether teachers' views varied significantly across categories.

Section 2. Teachers' views about senior science enrolments

Science teachers were presented with a set of 19 items outlining possible influences on enrolment declines. The items were distilled from the literature and designed to investigate four domains of influence on students' enrolment decisions:

- students' experiences of science teachers and science classes;
- characteristics of students;
- characteristics of the curriculum;
- students' views about university science courses and careers.

Additional items explored teachers' views about the influence of mass media images of science and scientists, parental support, efforts by organisations to promote science, and possible perceptions that science may have a negative impact on society. To distinguish these 19 items from others in the science teacher survey, they are referred to as the Perceived Influences on Enrolment Declines (PIED) items.

The PIED items were presented as hypothetical statements about the causes of enrolment declines, prefaced by the following context and question:

The last fifteen years have seen substantial declines in the proportions of Australian students choosing senior physics, chemistry and biology subjects. Several factors have been suggested as contributing to these declines. How influential do you think the following suggested factors have been in contributing to the decline in science enrolments?

Teachers were asked to rate each item using a five point Likert-type response format according to whether they considered it to be 'not at all influential', 'not very influential', 'moderately influential', 'very influential' or 'extremely influential' in contributing to the declines. Responses were coded from 1 (Not at all influential) to 5 (Extremely influential).

The PIED items were not originally designed to constitute a robust and internally coherent scale, but rather a means of identifying foci for further exploration in the Phase Two student survey. Nevertheless, the internal consistency (Cronbach's alpha) of this set of items was 0.76, indicating good reliability for a researcher-designed scale (Cooksey, 2007). Internal reliability was further inspected using 'Cronbach's alpha if item deleted', though no individual item was found to significantly lower scale reliability.

Section 3. Sources of advice and information about choosing science

Teachers were asked their opinions about the influence on students' decisions of advice from five sources: careers advisors; parents and other adult relatives; science teachers; friends and peers in their year level, and older students or siblings. Again, teachers responded via a five point Likert-type format with the options 'not at all influential', 'not very influential', 'moderately influential', 'very influential', and 'extremely influential'. Responses were also coded from 1 to 5 and means scores and standard errors calculated for each item.

Section 4. How to encourage greater participation in science

Teachers were invited to suggest strategies they believed would encourage greater participation in science subjects. Their qualitative responses were coded thematically using the constant comparative method (Maykut & Morehouse, 1994).

Phase Two: Year 10 Student Survey

The student sample

Teachers completing the Science Teacher Survey were invited to nominate their schools for participation in Phase Two. From the 243 schools nominated by teachers, a proportionally representative sample of schools was selected based on state/territory, sector and locality representation. Permission was then sought from relevant education authorities to include students from these schools in the study.

Each school was sent a package comprising invitations to participate, information sheets, ethics documentation, parental and student permission notes and instructions to the coordinating teacher. Coordinating teachers were asked to invite Year 10 students who were continuing to Year 11 the following year to participate in the survey. The online survey was opened in November 2007 to ensure that respondents had completed their exams (where appropriate) and had already chosen their subjects for Year 11. The survey was hosted online and accessed by students under the supervision of the school's coordinating teacher. The teacher read out a set of instructions (Appendix 3) and provided students with the survey web-address and login password.

A total of 3801 respondents attempted the student survey. Cleaning of the data resulted in a final sample of 3759 Year 10 students. A breakdown of sample characteristics is shown in Table 2.2. Respondents were fairly evenly split across the sexes, with 53% girls and 47% boys. The greatest representations were from NSW, QLD and SA, which was generally consistent with the representation of teachers in Phase One. Close to half the students attended capital city schools, with about 35% from rural or remote areas. Just over 75% attended coeducational schools, while approximately 42% were from Government schools, with Independent and Catholic systemic schools contributing about 37% and 21% of the sample respectively.

The *Choosing Science* sample represented about 1.4% of the 2007 Australian Year 10 cohort of 269 293 students (ABS, 2008). Compared to this cohort, the sample had a slightly higher representation of females (49% ABS). It had a greater representation from South Australia (ABS 7.7%) and a lower representation from Victoria (ABS 23.8%). Other state/territory proportions were with +/-3% of ABS figures. The sample was over-represented by students from the Independent school sector (ABS 17%) and underrepresented by students from government schools (ABS 61%).

The differences between the intended sample profile and the final profile were due to variations in the numbers of students from selected schools completing the survey and the late withdrawal of some schools from the study. Speculation about the degree to which such differences may have influenced results from whole sample analyses should be considered in the light of results from analyses of sex, state/territory and sector differences in subsequent chapters of the report.

Table 2.2: Breakdown of student respondents by sex, state, school type, school sector and location variables.

		Girls		Boys		Total	
		Count	*% of total*	Count	*% of total*	Count	*% of total*
State/ Territory	ACT	92	*2.4*	75	*2.00*	167	*4.4*
	NSW	576	*15.3*	447	*11.90*	1023	*27.2*
	NT	30	*0.8*	35	*0.90*	65	*1.7*
	QLD	466	*12.4*	374	*9.90*	840	*22.3*
	SA	306	*8.1*	422	*11.20*	728	*19.4*
	TAS	68	*1.8*	47	*1.30*	115	*3.1*
	VIC	280	*7.4*	224	*6.00*	504	*13.4*
	WA	175	*4.7*	141	*3.80*	316	*8.4*
Location	Capital city	863	*23*	878	*23.40*	1741	*46.3*
	Non-capital city [a]	387	*10.3*	323	*8.60*	710	*18.9*
	Rural city/ large town [b]	482	*12.8*	355	*9.40*	837	*22.3*
	Rural/ remote town [c]	262	*7*	209	*5.60*	471	*12.5*
Sector	Catholic system	485	*12.9*	297	*7.90*	782	*20.8*
	Government	775	*20.6*	819	*21.80*	1594	*42.4*
	Independent	734	*19.5*	649	*17.30*	1383	*36.8*
School Type	Co-educational	1474	*39.2*	1371	*36.50*	2845	*75.7*
	Single sex	520	*13.8*	394	*10.50*	914	*24.3*
	Total	1994	*53*	1765	*47.00*	**3759**	***100***

[a] Population > 25 000; [b] Population from 10 000 to 25 000; [c] Population < 10 000

The TOSRA comparison sample

One of the main aims of *Choosing Science* was to investigate whether students' attitudes towards science and science careers had also declined in concert with enrolments. In order to compare contemporary students' attitudes to science with those of an earlier cohort, reliable benchmark data were needed. The earlier study also had to be replicable in terms of the sample characteristics and methodology. Fortunately, Fraser's 1977 TOSRA study met these criteria. Fraser used TOSRA to measure the attitudes of 324 Year 10 students from 11 high schools in the Sydney metropolitan area. To ensure his sample was representative of the population, Fraser included five government coeducational high schools and six single-sex high schools; one boys' school and one girls' school from each of the three sectors: Government;

Catholic; and Independent. At each level the sample contained approximately equal numbers of boys and girls. Although exact student numbers from each school are unknown (Fraser, pers. comm. 17/11/08), a sample size of 324 from 11 schools suggests an average of about 30 students per school. A comparable sample of students from 11 Sydney metropolitan schools was drawn from *Choosing Science* respondents.

Table 2.3 compares characteristics of the target sample based on Fraser's 1977 cohort with those of the 2007 *Choosing Science* sample. While not an exact match to the target sample, the table shows that the contemporary cohort had very similar characteristics. In an effort to further ensure the representativeness of the *Choosing Science* sample, and thereby enhance the external validity of findings, an additional 2007 data set (B sample) was constructed by substituting alternative cases from schools similar in characteristics to those identified in Table 2.3. Negligible differences were found between the A and B samples in terms of mean scores on the four scales.

Table 2.3: Characteristics of the target sample (based on Fraser's 1977 study) and the comparable *Choosing Science* TOSRA sample.

<table>
<tr><th></th><th></th><th colspan="6">School Sector</th><th></th></tr>
<tr><th></th><th></th><th colspan="2">Government</th><th colspan="2">Catholic</th><th colspan="2">Independent</th><th></th></tr>
<tr><th></th><th>School Type</th><th>Male</th><th>Female</th><th>Male</th><th>Female</th><th>Male</th><th>Female</th><th>Total</th></tr>
<tr><td rowspan="3">Target TOSRA sample (based on Fraser's 1977 sample)</td><td>Co-ed</td><td>~70</td><td>~70</td><td>0</td><td>0</td><td>0</td><td>0</td><td>~140</td></tr>
<tr><td>Single-sex</td><td>~30</td><td>~30</td><td>~30</td><td>~30</td><td>~30</td><td>~30</td><td>~180</td></tr>
<tr><td>Total</td><td colspan="2">~200</td><td colspan="2">~60</td><td colspan="2">~60</td><td>~320</td></tr>
<tr><td rowspan="3">Choosing Science TOSRA sample, (2007)</td><td>Co-ed</td><td>67</td><td>67</td><td>0</td><td>0</td><td>0</td><td>0</td><td>134</td></tr>
<tr><td>Single-sex</td><td>30</td><td>30</td><td>30</td><td>29</td><td>25</td><td>30</td><td>174</td></tr>
<tr><td>Total</td><td colspan="2">194</td><td colspan="2">59</td><td colspan="2">55</td><td>308</td></tr>
</table>

Student Survey Instrument design

The Year 10 Student Survey instrument was designed as a web-based questionnaire consisting of five sections.

Section 1. About you and your school

This section collected data on respondent and school characteristics including sex, school type, school sector, state/territory and geographic location. The data were used to investigate whether students' views varied significantly across categories.

Section 2. Your experiences of school science

Students were asked to respond via a five point Likert-type format to six items investigating their experiences of school science to date. The items are listed in Appendix 2. One item - "I like school science better than most other school subjects" - was borrowed from the Relevance of Science Education (ROSE) study (Schreiner & Sjøberg, 2007), an international study exploring students' attitudes to science.

Section 3. What you think about science

This section consisted of 40 items selected from the Test of Science Related Attitudes (TOSRA) instrument (Fraser, 1978). The items came from four TOSRA scales: Social Implications of Science; Normality of Scientists; Enjoyment of Science Lesson and Career Interest in Science (Appendix 2). Each of the TOSRA scales consisted of five positively and five negatively worded statements designed to measure student attitudes to the relevant construct. Students responded via a five point Likert-type format with the following options: Strongly disagree (1), Disagree (2), Unsure (3), Agree (4) and Strongly agree (5). Responses to the TOSRA items were also used to gauge attitudes to science and science careers within the 2007 cohort.

Section 4. Your decisions about taking science

Students were asked to identify their science choices for Year 11. Depending on the subject(s) chosen, they were directed to one of five sub-sections of the web-survey consisting of 17 questions relating to specific options: physics, chemistry, biology, other science and no science. The wording in each section varied slightly depending on the option. For example, those choosing physics were asked to indicate their level of agreement with the statement 'I chose physics because I had good science teachers', whereas the equivalent item for non-science students was: 'I chose no science courses because I didn't have good science teachers.' The questions investigated students' rationales for their decisions and their perceptions of the influence of others, including their mothers, fathers, older siblings, close friends, older students, science teachers, and careers advisors.

Section 5. Science and your future

This section comprised eight questions focusing on students' ideas about science careers, including their perceptions about career salaries and qualifications, and their sources of information about science careers. Students responded to seven of the questions using a five point Likert-type format. A second ROSE item - 'School science has opened my eyes to new and exciting jobs' was included in this section. The final question: 'If you could change one thing about high school science to encourage more students to choose it in Year 11, what would you change?' invited open responses from all students.

Data analyses

A variety of strategies were used in analysing data. Simple frequency analyses were employed to describe sample profiles. Comparisons across discrete categories were drawn using crosstabulations, while variations in responses to ordinal Likert-type items across independent variables such as sex, location or school types were identified using parametric techniques such as ANOVAs and MANOVAs, in parallel with non-parametric alternatives such as chi-squared tests. Principal Components Analysis (PCA) was used to identify underlying constructs within the set of 19 PIED items, while a multiple regression analysis was undertaken to summarise those characteristics contributing most to students' aspirations to take university science courses. Statistical results for all tests showing meaningful significant results are reported as footnotes. These treatments and other considerations are described below.

Criteria for identifying meaningful significant differences

Because of the large sample size and the number and types of statistical tests undertaken, a stringent level of significance of **$p < 0.001$** was adopted. This helped prevent erroneous claims of significance, with a probability of only one in 1000 that the reported differences occurred by chance. Furthermore, significant differences are reported only where they are also meaningful, that is, where the differences are large enough to have a practical, meaningful utility. This was determined by interpretation of effect sizes according to conventions for the particular analytical procedures used. Because of the large number of analyses conducted, those with non-significant results and/or where the effect size was extremely small are generally mentioned only briefly, and the associated statistical results are not reported.

Likert-type scales and measurement level

Most survey items in this study invited responses via Likert-type formats. This decision was due mainly to the incorporation of TOSRA and ROSE items, which were originally designed using such formats. Once the decision to use these had been made, it was decided for the sake of consistency to use Likert-type formats for related items. While it is common practice in social science research to treat the ordinal level data generated by these formats as interval level data, there is also some debate about whether such data can be analysed using parametric methods. The key area of contention is the assumption that intervals between the scale values - for example, between 'Strongly Agree' and 'Agree' - are all equal (see Carifio and Perla, 2007 for an summary of this debate).

Both parametric and non-parametric methods were used in this study to analyse data from Likert-type items. The use of parametric methods such as factor analysis, ANOVAs and MANOVAs to analyse such data is supported by the large body of evidence endorsing the robustness of parametric analysis of Likert-type responses (e.g. Glass, Peckham & Sanders, 1972; Jacard & Wan, 1996; Zumbo & Zimmerman, 1993).

Nevertheless, a number of decisions were made to further ensure the integrity of the results. First, Likert-type response formats were only used where they identified continuous underlying constructs. Second, parametric analyses were supported by comparable non-parametric approaches, as recommended by Grace-Martin (2008), and findings of both reported. Finally, the decision to employ the more stringent criterion for statistical significance, and report results only where they were also statistically meaningful, ensured the findings reported here are only those in which we have a high level of confidence.

Crosstabulations and chi square tests

Students' responses to some items were crosstabulated with categorical variables including sex, state/territory, school sector, school type and location. Patterns of differences across these variables were analysed using chi-square contingency table tests. Where meaningful significant differences were found, adjusted standardised residuals (ASRs) were used to evaluate the sources of the differences detected by significant chi-square relationships. Adjusted standardised residuals greater than

+3.30 or less than –3.30 indicate (at 99.9% probability level) that individual cell counts are significantly different to those expected if there was no association between the variables, with those greater than +2.58 or less than - 2.58 suggestive of significant differences (at a probability level between 99 and 99.9%). The magnitude of the ASR (in either + or - direction) reflects the size of the difference between observed and expected counts.

In the case of chi-square tests, Cramer's V was used as a measure of effect size. Cramer's V statistics were interpreted as indicating small, medium or large effect sizes according to Cohen's criteria (1988 cited in Gravetter & Wallnau, 2005 p. 475), detailed in Table 2.4.

Table 2.4: Interpretation criteria for Cramer's V measure of effect size for chi-square contingency tables. (Source: Gravetter & Wallnau, 2005 p. 475)

Degrees of freedom	Cramer's V statistic	Effect size
1	$0.10<V<0.30$ $0.30<V<0.50$ $V>0.50$	small medium large
2	$0.07<V<0.21$ $0.21<V<0.35$ $V>0.35$	small medium large
3	$0.06<V<0.17$ $0.17<V<0.29$ $V>0.29$	small medium large

a Degrees of freedom is the smaller of (Row – 1) or (Column -1)

Significant differences below the threshold of a "small" effect are generally not reported, as they are unlikely to reflect meaningful differences.

Principal Components Analysis (PCA)

A principal components analysis (PCA) was carried out to identify any underlying constructs within the set of 19 PIED items, and if possible to reduce these items to a more manageable number of factors. For each PCA, the 'eigenvalue greater than 1.0' rule was applied and scree plots generated to help determine the most appropriate number of components to interpret. Analyses were conducted using Promax rotation to produce the most interpretable component structures, while allowing for the possibility of correlated components. Results of the PCA are discussed in Chapter 3.

Analyses of Variance

In many cases, mean scores for Likert-type items were compared across multiple dependent variables or groups of respondents using MANOVAs. In the few instances where only a single dependent variable was under consideration, standard ANOVAs or ANCOVAs were used. Where a MANOVA revealed significant multivariate differences, individual univariate comparisons of means were undertaken. For nominal independent variables such as sex, school type, school sector, location and state/territory, sets of three MANOVAs were generally used. One MANOVA was conducted using sex, school type and school sector as independent variables, and examining any interaction effects between these variables. Two further MANOVAs were conducted for school location and state/territory respectively.

Due to the large sample size, the MANOVAs should be robust to the modest violations of univariate normality (Tabachnick & Fidell, 2001) apparent among the individual dependent variables. Multivariate outliers detected by Mahalanobis distances were deleted from analyses as recommended (Hair, Anderson, Tatham, & Black, 1995; Tabachnick & Fidell, 2001). Multicollinearity and singularity were verified by examining correlations between variables and homogeneity of variance was checked. Box's M was disregarded as it is too strict for the large sample size in this study (Tabachnick & Fidell, 2001, p. 80) in favour of Levene's test, though Levene's test was sometimes significant at $p<0.001$. In these cases the F-max test was applied, and variances considered acceptable if the ratio of largest:smallest N was less than 4:1 and the ratio of their variances less than 10:1 (generally this was less than 2:1). The exception was in making some comparisons across state/territories, where the smallest (NT) group size was around one ninth the largest (NSW). For significant results in these cases the ratio of NSW:NT variances was checked and was less than 1.1:1. In these instances, equal variances were not assumed in relevant post hoc tests.

In the case of comparisons of means, partial eta squared (abbreviated as ηp2) was used as a measure of effect size. Values of ηp2 range from 0 to 1, and the closer the value to 1, the larger the effect; that is, the stronger the association between the variables. Significant differences with ηp2 less than 0.01 were generally not reported, as any significant association between the variables is likely to be so weak as to be of little practical or theoretical consequence. Descriptors for ηp2 used in this report follow Stevens (1992, citing Cohen 1977) with values above 0.01 interpreted as a small effect, above 0.06 as a moderate effect, and above 0.14 as a large effect.

Multiple Regression

Standard multiple regression was used to investigate potential predictors of students' intentions to study science at university. This technique shows how much of the variance in the dependent variable (student responses to the item asking about their university study plans) can be explained by a number of independent variables, such as perceived ability and/or enjoyment of science and so forth. Assumptions of multicollinearity, singularity, normality and linearity were checked and multivariate outliers removed from the analyses.

Qualitative data analysis

Both surveys included open response opportunities for respondents to record views about what could be done to improve participation in science courses. The responses were analysed, collated and coded using the constant comparative method (Maykut & Morehouse, 1994). For each survey this process involved two research assistants independently identifying and coding themes from a sample of 100 responses. The researchers then met with the project coordinator to compare interpretations and reach a consensus on the final sets of codes used to analyse the full data sets. Once coding was completed, the team met for a final comparison of interpretations. Results are presented in figures showing theme frequency and are accompanied by examples of typical comments.

Interpreting tables and figures

This report presents data using several types of figures and tables. Where crosstabulations generated significant meaningful results, comparisons between frequencies or percentages of responses are presented using either simple or cumulative bar charts.

Means and standard errors of multiple items are generally presented as plot points with standard error bars. This gives a picture of the relationship between means of different variables, which can be more readily interpreted than tables. These figures show means of the responses to the Likert-type items, often ranked in descending order of means. In order to present much of the data together with the full item description, the usual conventions are reversed, with items placed on the Y-axis and the mean values on the X-axis. A vertical dotted line indicates the middle point, with means to the right of this indicating increasing agreement, and means to the left indicating increasing disagreement.

The error bars on these figures indicate two standard errors above and below the mean value, which corresponds approximately to a 95% confidence interval. In visually interpreting these figures, the following rules of thumb can be applied (following Cumming, Fidler, & Vaux, 2007; Cumming & Finch, 2005). If error bars for two means overlap at all, the two means are not significantly different according to the $p<0.001$ alpha level adopted in this study. A gap between two error bars greater than about one third the average length of one arm implies a significant difference between means at $p<0.001$ (Cumming & Finch, 2005, p. 176). The bigger the gap, the smaller the p value and the more likely there is a difference between the means at $p<0.001$.

Chapter 3 : Science teachers' perspectives on enrolment declines

Introduction

Secondary science teachers are in a unique position to observe the deliberations of Year 10 students choosing their subjects for senior school. In Phase One of the study secondary science teachers were invited to complete an online survey concerning their perceptions of the reasons behind enrolment declines, and suggesting ways of improving participation. Teachers' opinions were analysed and the findings used to inform Phase Two of the study. The science teacher survey was designed to address four questions:

T1: What do science teachers see as the key influences contributing to declines in science enrolments?

T2: Do teachers' perceptions vary significantly across states/territories, school sectors or locations?

T3: Which sources of advice about science courses do teachers consider most influential in students' deliberations?

T4: What advice do teachers have for increasing enrolments in senior science courses?

T1: What do science teachers see as the key influences contributing to declines in science enrolments?

Respondents were provided with a set of 19 statements outlining plausible reasons for the declines in physics, chemistry and biology enrolments over the previous fifteen years. They were asked to indicate via a Likert-type response format how influential they believed each was in contributing to these declines.

Teachers' mean ratings of the 19 Perceived Influence on Enrolment Declines (PIED) items (see Chapter 2) are reported in Figure 3.1.

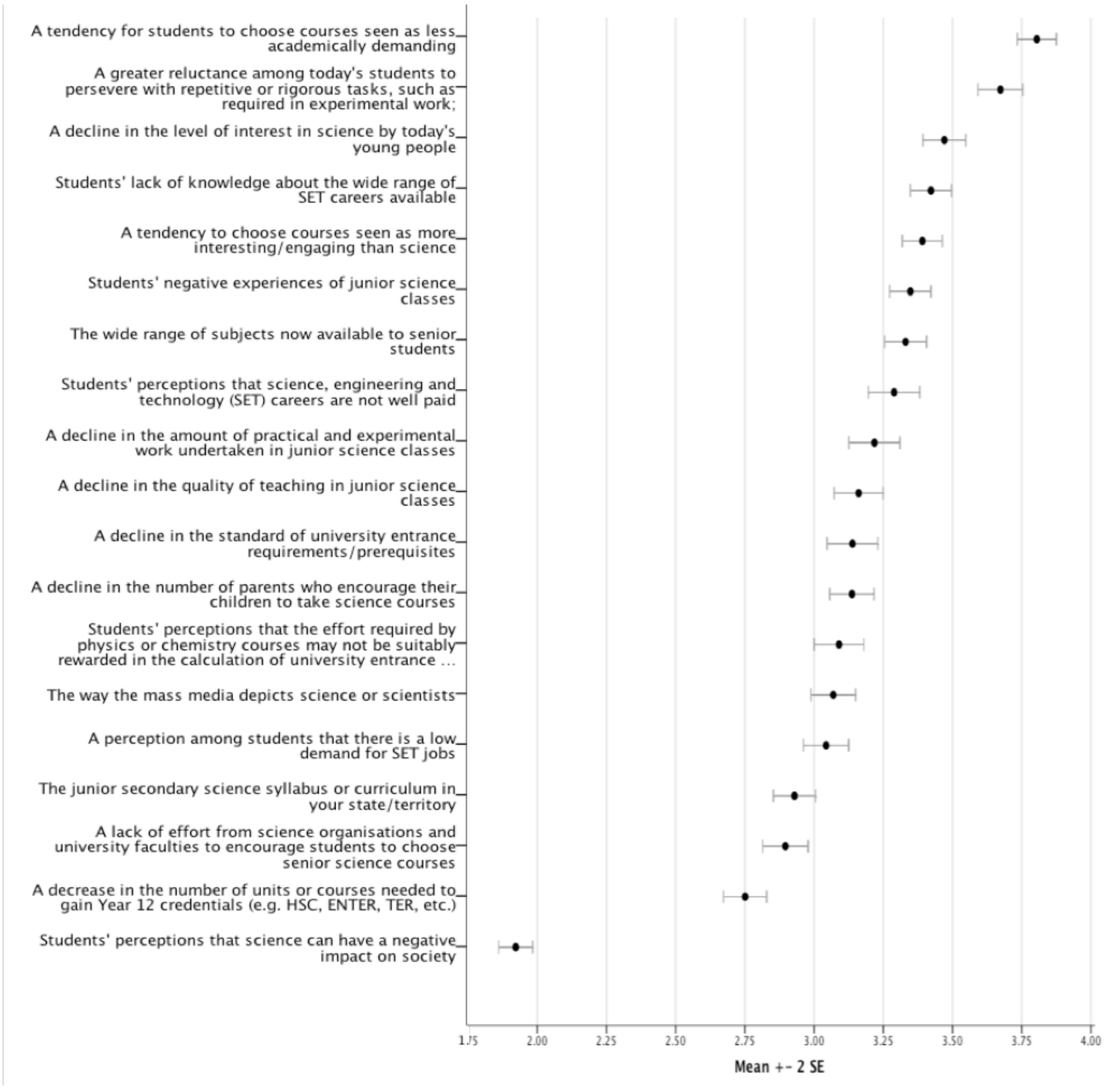

Figure 3.1: Mean teacher ratings of the influence of PIED items on science enrolment declines. [Response scale: 1=Not at all influential, 2 = not very influential, 3 = moderately influential, 4 = very influential, 5 = extremely influential]

Fifteen items scored mean ratings above 3 (moderately influential). Apart from the first two and last two items, there were relatively small differences in mean ratings between many items as shown by the overlapping error bars. This suggests that teachers feel the enrolment declines to be due to a wide range of influences, or perhaps a close interactivity of influences. Alternatively, the pattern may be due to a lack of consensus among teachers as to the causes of enrolment declines. Nevertheless, it is possible to tease out some patterns in the rating order.

In order to examine in more detail the patterns of response for each question, the frequencies for each response category are shown in decreasing order of mean agreement in Figure 3.2.

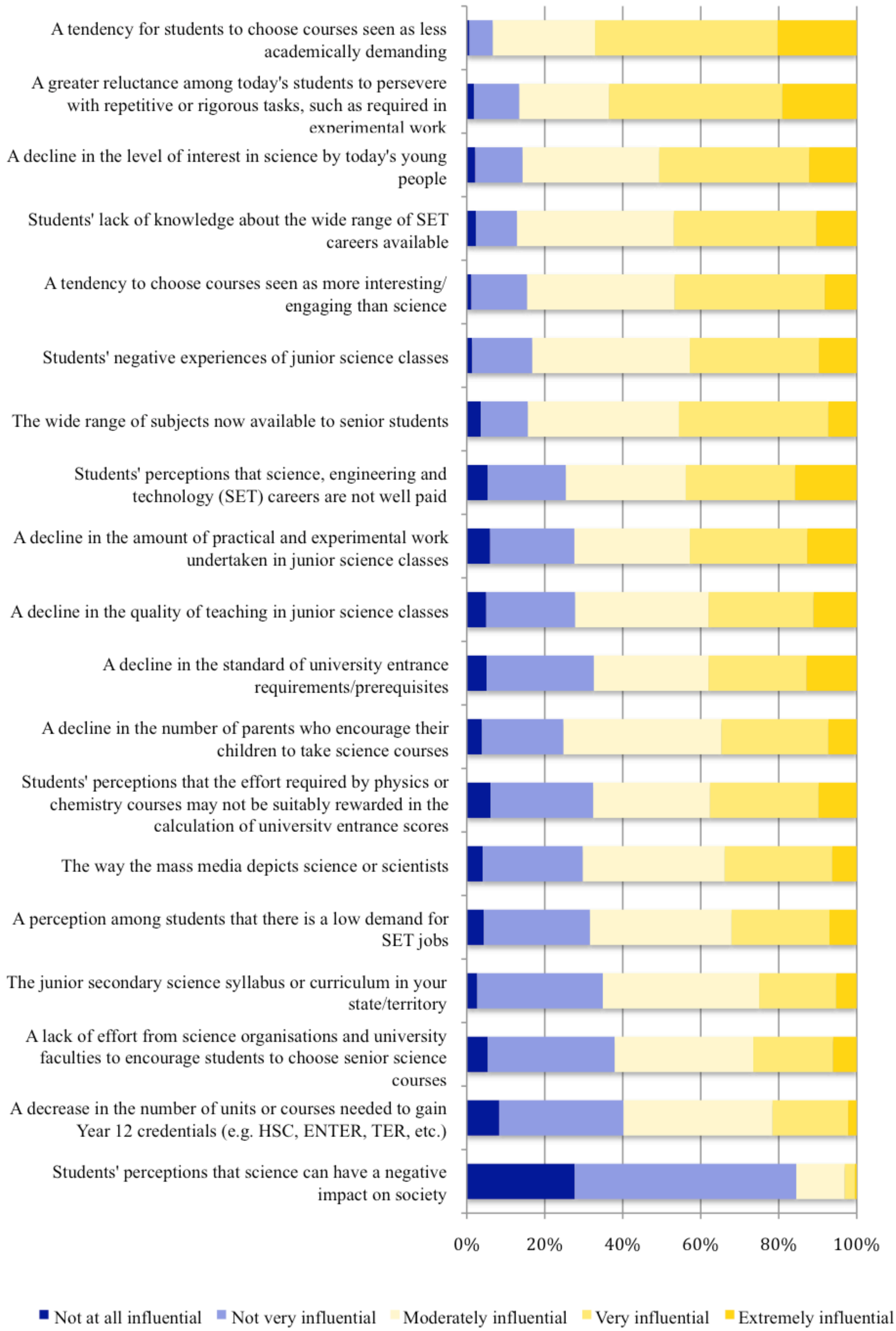

Figure 3.2: Percentage breakdowns of science teacher ratings of PIED items.

The influence of students' preferences for easier of more attractive subjects

The three highest rated items in Figures 3.1 and 3.2 suggest that science teachers believe the locus of influence on enrolment declines resides principally with students rather than with teachers, science curricula or career prospects. Figure 3.2 shows that around two thirds of teachers considered students' preferences for less academically demanding courses to have been very or extremely influential in the declines. About 62% felt that students' reluctance to undertake courses requiring perseverance with rigorous tasks had been very or extremely influential. Respondents also considered that declining interest in science has been a substantial influence, and that students are increasingly choosing subjects seen as more engaging and interesting than science. These four items, ranked among the top five, suggest teachers see the context for decisions as shaped by the difficulty of, and declining interest in, science on one hand and a multiplicity of more appealing alternatives on the other. The strength and pervasiveness of this opinion among teachers prompted a comparative investigation of enrolment patterns in non-science subjects over the last fifteen years. The results of this investigation are discussed in Chapter 8.

The influence of careers and university aspirations

Three items related to career motivations for choosing or not choosing science courses. Teacher rated two of these items quite highly, with 'students' lack of knowledge about the wide range of SET careers available' and 'students' perceptions that science, engineering and technology (SET) careers are not well paid' ranked fourth and eighth respectively. Figure 3.2 shows that a relatively high percentage of respondents (15.6%) considered students' perceptions of low pay to be 'extremely influential' in their decisions. Only the two highest rating items attracted higher proportions of teachers selecting this scale option. This finding reflects anecdotal evidence about the relatively low salaries of science careers, prompting the inclusion of related items in the Phase Two student survey. In contrast, teachers were less inclined to attribute the enrolment declines to students' perceptions that 'there is a low demand for SET jobs' (3.03).

Two other career oriented items concerned university influences: 'A decline in the standard of university entrance requirements/prerequisites' and 'Students' perceptions that the effort required by physics or chemistry courses may not be suitably rewarded in the calculation of university entrance scores'. Mean ratings for these items indicate that teachers felt they were only of moderate influence on enrolment declines.

The quality of science teaching

Respondents were less inclined to attribute the decrease in enrolments to science teaching quality than to student characteristics. Figure 3.1 shows two pertinent items: 'Students' negative experiences of junior science classes' and 'A decline in the quality of teaching in junior science classes' ranked sixth and tenth respectively. While mean ratings were below those attributed to student characteristics, Figure 3.2 shows that 42.8% and 38.5% of respondents felt these issues were either 'very' or 'extremely' influential in contributing to the declines. These are substantial proportions of respondents, certainly enough to ensure that student perceptions of teacher characteristics were worth exploring in Phase Two.

Curriculum influences

Four items referred to curriculum issues. Of these, Figure 3.1 shows that respondents considered the wide range of subjects available to senior students quite influential in decisions not to take science. A second item; 'A decline in the amount of practical and experimental work undertaken in junior science classes' was believed to be 'extremely influential' by 13.2% of respondents. Finally, state/territory science syllabuses and 'A decrease in the number of units or courses needed to gain Year 12 credentials' were not considered particularly influential.

Other influences

The domains of student characteristics, teachers and teaching, career/university considerations and curriculum influences accounted for all items considered by teachers to make a substantial contribution to declines in science enrolments. Of the remaining items, a decline in parental encouragement was felt by around 35% of teachers to be very or extremely influential, while a similar proportion felt that mass media depictions of science and scientists were at least very influential. Relatively few teachers believed that enrolment declines were attributable to a 'Lack of effort from science organisations and university faculties to encourage students to choose senior science'. The statement eliciting least agreement was that the declines were due to 'students' perceptions that science can have a negative impact on society'.

T2: Do teachers' perceptions vary significantly across states/territories, school sectors or locations?

The study sought to explore differences in teacher ratings across three independent variables: states/territories, school sectors and locations. This exploration was undertaken in two stages. First, a principal components analysis (PCA) was carried out to identify any underlying constructs among the PIED items and therefore reduce the items to a more manageable number of factors. Second, MANOVAs were conducted using the factor means to identify any significant differences in teachers' responses across states/territories, school sectors and locations.

For the PCA, one item (perceptions that science can have a negative impact on society) was excluded as inconsistent. The remaining 18 items loaded on five components, explaining 53% of the variation. The underlying constructs identified by the components were labelled as follows:

1. Increased diversity of subject options;
2. Lack of interest, enthusiasm and encouragement towards science;
3. Insufficient reward for effort;
4. Negative perceptions and experiences of junior science;
5. Poor perception of and knowledge about science careers.

The MANOVAs revealed no significant differences across school sector, state/territory or rural/urban location independent variables, indicating that teachers' views about the causes of enrolment declines were not closely associated with these sample characteristics.

T3: Which sources of advice about science courses do teachers consider most influential in students' deliberations?

Teachers were asked to rate the influence of advice from parents, friends/peers, older students, science teachers and careers advisors on students' decisions about enrolling in science courses. Again, the influence of advice was rated a five-point scale from 1 (Not at all influential) to 5 (Extremely influential).

Figure 3.3 shows the mean ratings of perceived influence and Figure 3.4 the percentage breakdown of responses to each question. These figures indicate that teachers tended to consider advice from friends and peers to be the most influential, followed by advice from older students or siblings. The advice of parents was seen by teachers as having less influence than advice from within students' own age group, though more so than that of the science teachers themselves. Respondents regarded the advice from Careers Advisers as having the least influence.

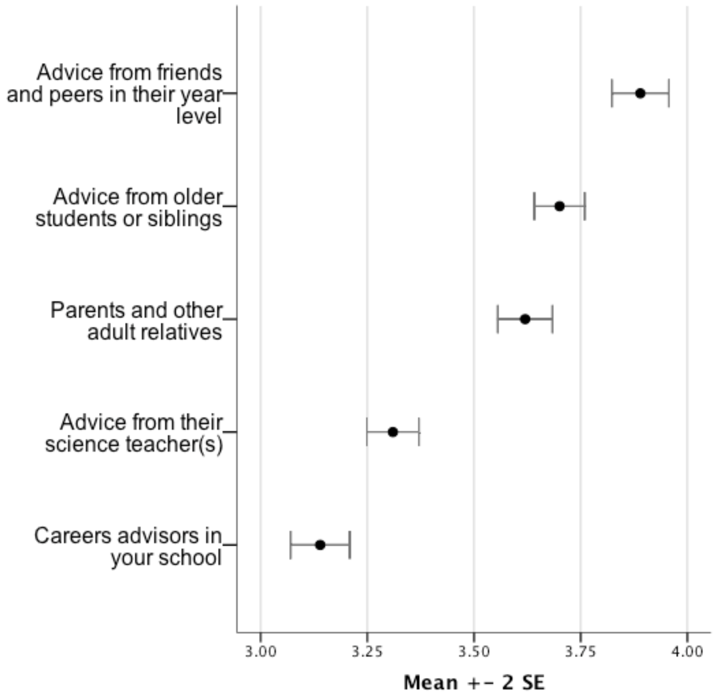

Figure 3.3: Science teachers' mean ratings of the influence of advice from a range of sources. [Response scale: 1=Not at all influential, 2 = not very influential, 3 = moderately influential, 4 = very influential, 5 = extremely influential].

As shown in Figure 3.4, around 22% of respondents considered the advice of friends and peers to be extremely influential. In contrast, only 5% believed that advice from science teachers is extremely influential. Around 20% of respondents considered the advice from Careers Advisors to have very little influence.

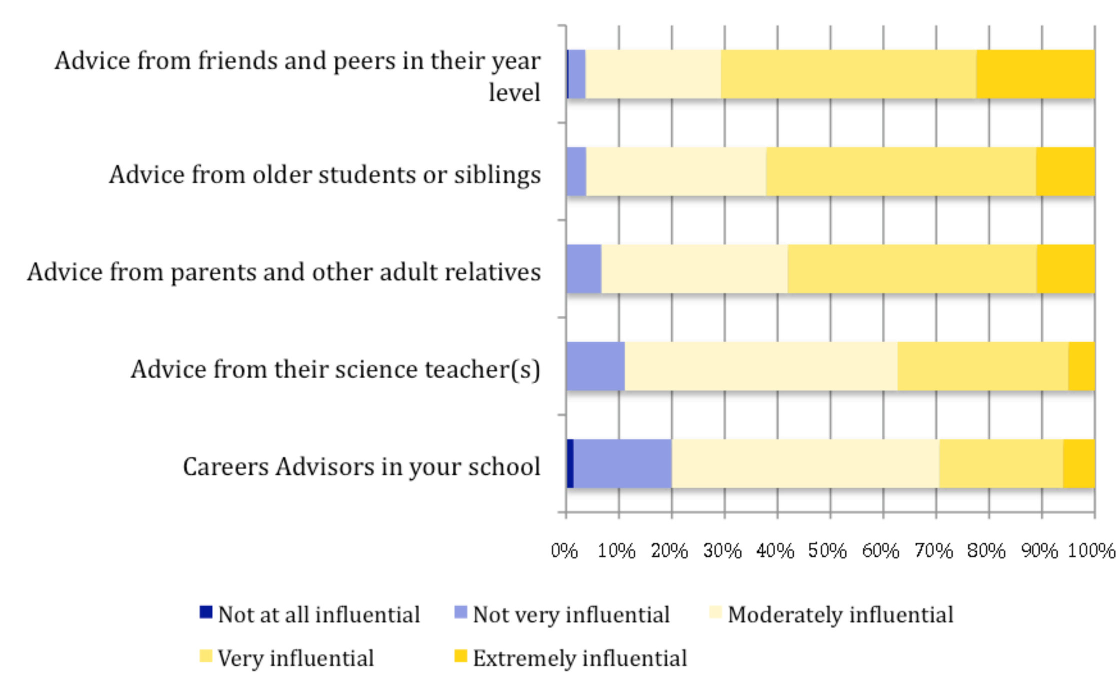

Figure 3.4: Percentage breakdown of science teacher ratings of the influence of advice from a range of sources.

In Phase Two of the study, students were also asked about the influence of others on their enrolment decisions. Chapter 6 includes a comparison between students' and teachers' perceptions on this issue.

T4: What advice do teachers have for increasing enrolments in senior science courses?

Teachers were invited to suggest strategies they believe would encourage more students to enrol in senior science courses. These could include successful innovations they had already implemented or observed. A total of 594 suggestions were contributed by 382 teachers. The themes emerging from the constant comparative coding process are ranked in Figure 3.5, in order of frequency of related suggestions. The figure the top three themes were: increasing the relevance, enjoyment and interest of school science, facilitating links with real scientists and educating students about science careers.

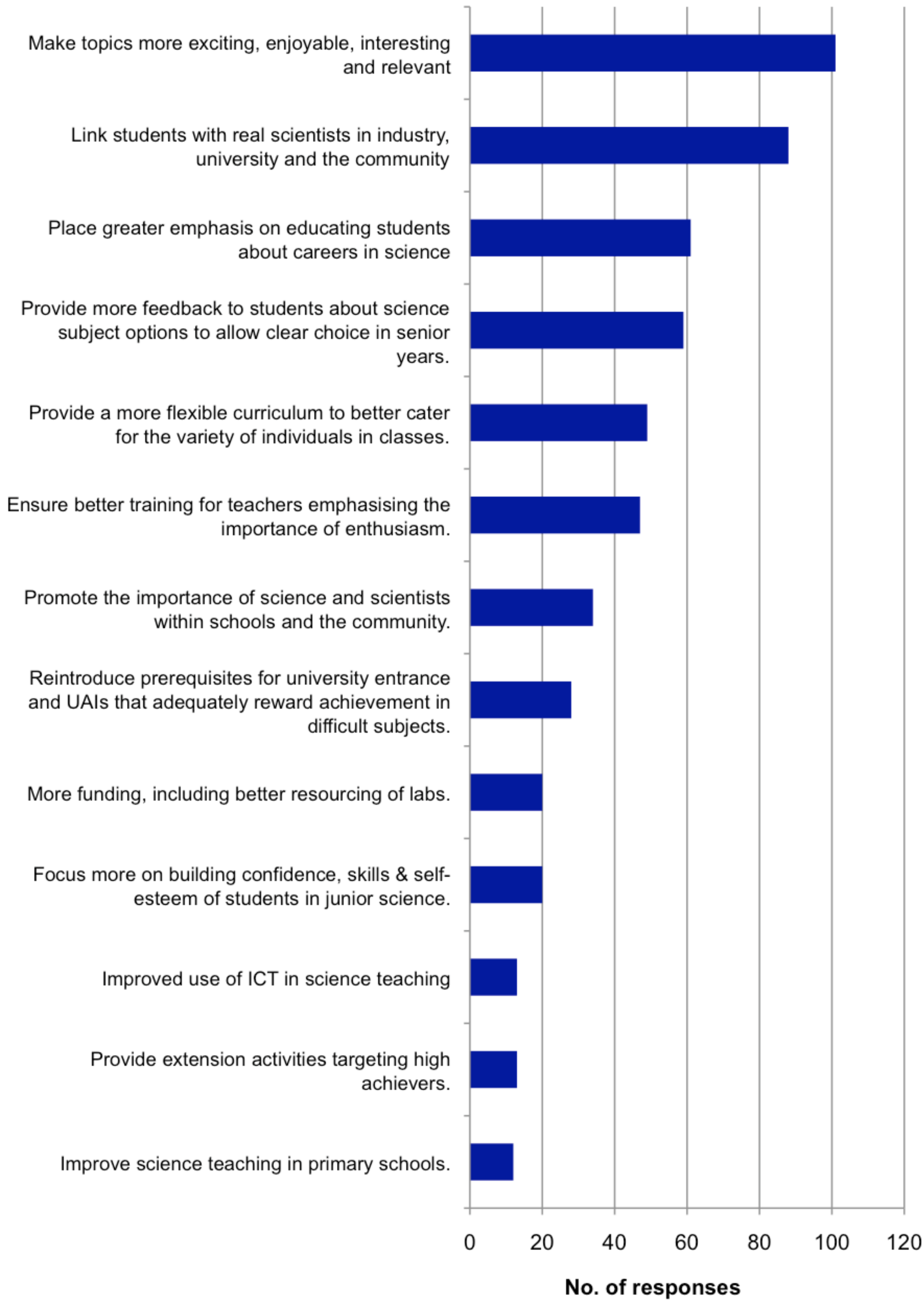

Figure 3.5: Teachers' suggestions for strategies to encourage more students to choose senior science courses

Increase relevance, enjoyment and interest

As shown in Figure 3.5, many respondents believe that school science needs to be made more interesting, enjoyable and relevant to students. For example:

> *The best strategy in my opinion is to motivate students in junior secondary with interesting topics and enthusiastic teaching. Positive promotion of science in school newsletters and local press is helpful. – Science teacher, NSW*

> *[There should be a] greater emphasis on hands-on and relevant science. I think at the junior level we spend way too much time getting into the nitty gritty of explanations rather than just satisfying the students' curiosity on all things. - Science teacher, Victoria*

In particular, many teachers suggested that greater relevance could be achieved through context-based teaching and learning. For example:

> *Strategies need to … allow students to successfully implement appropriate skills and knowledge in a context that is relevant and meaningful to students. Our school is trialling a theme-based approach to science for Year 9 students. These themes are: Health; The World; and Technology. Within each theme, students complete activities drawn from the knowledge areas of biology, physics, chemistry and earth sciences. - Science teacher, Victoria*

> *In the Junior Secondary science programme science topics need to be set in meaningful contexts for students. They have to be given the opportunity to engage in assessment tasks in modes which suit their learning styles and which confer some personal decision making about directions they wish to take. They have to have fun doing science. - Science teacher, South Australia*

> *[Incorporate] contextual programming in Junior Science. Once programmes were written using contexts relevant to students in one of my previous schools, a huge impact was observed on students' motivation and keenness to pursue science at a senior level. - Science teacher, NSW.*

On a related theme, Figure 3.5 also shows that a substantial number of teachers considered that science curricula should be more flexible to cater for a greater variety of students. Teachers also recommended increasing the quality and amount of practical activity in science lessons as a way of improving engagement and relevance. For example:

> *Increase practical work in junior science, particularly in year 10. More focus on science skills being useful in 'real world' situations instead of knowledge for knowledge' sake. – Science teacher, NSW.*

> *Doing lots of practical hands-on activities in junior science classes. Talking about the everyday relevance of the science … and being enthusiastic. - Science teacher, Tasmania.*

Links with real scientists

Many respondents also suggested that establishing links with real scientists and making students more aware of science careers will encourage more students to choose senior science subjects. For example:

> *This year in Year 8 we brought in two scientists to talk to the students about their jobs. We also bring past scholars back in to talk to Yr10 students re careers. I think these strategies are very useful in promoting science as a career. – Science teacher, South Australia.*

> *Bring in ex-students who have completed Science/Technology courses and who are enthusiastic communicators to address Year 10 students just before they choose their upper school courses. Very successful. – Science teacher, Western Australia.*

> *A series of guest lectures (where) scientists from various disciplines go into schools and talk to students about what they do and the educational pathways they took to get there. This should happen at the junior levels (7 – 10). Come and try day - have more work experience available in the Science fields*
> *- Science Teacher, Victoria*

Educating students about science careers

A substantial number of respondents suggested that education about science careers could be improved. They also recommended that teachers, careers advisors and parents should all be sources of accurate advice:

> *[Students need] better careers advice including a careers adviser who knows the prerequisites for subjects and can give knowledgeable advice on the levels of maths needed for senior sciences, especially physics… Many students are receiving incorrect careers advice or are choosing their subjects based on their parents advice instead of going with what they are interested in.- Science Teacher, Victoria*

> *In Year 10, we have a Careers in Science program where students pick a career in each of the three major science strands and investigate pay, opportunities, required skills and study etc., Then [they] present finding to the class- this exposes students to the benefits of pursuing science. – Science teacher, South Australia.*

> *We need to educate the careers counsellors about the benefits to students of studying science! – Science teacher, Queensland*

Conclusion

The first phase of *Choosing Science* was conducted to identify teachers' perceptions of the reasons behind declines in senior secondary enrolments in science courses.

These perceptions are valuable for their own sake, as well as providing a guide to the types of themes which should be investigated further in Phase Two.

In general, science teachers' did not identify any single cause for the enrolment declines, tending instead to attribute influence across a range of possibilities. This suggests a diversity of opinion and underscores the complexity of the issue. Nevertheless, teachers attributed the greatest influence to students' preferences for choosing easier or more attractive courses from the wide range on offer. Teachers' ratings implicated student characteristics, such as their reluctance to choose 'difficult' subjects, as well as Year 11 curricula that provide students with many options. These views are explored further in Chapter 8.

Teachers also felt that enrolment declines were associated with a corresponding decline in the level of interest in science. This hypothesis was subsequently investigated in Phase Two and the results reported in Chapter 5. Teachers also considered enrolment declines to be related to students' perceptions about science careers, particularly their lack of knowledge about the range of SET careers available and perceptions that science careers are not well paid. Again, students' perceptions of these issues were investigated in Phase Two. Overall, teachers' opinions about the causes of science declines did not vary significantly with school sector, state/territory or degree of rurality.

With regard to teachers' perceptions about the influence of various sources of advice on students' decisions, respondents were overwhelmingly of the view that advice from friends, peers, older students and siblings is more influential than advice from adults. Advice from parents was seen as being more influential than that from science teachers, while advice from Careers Advisors was considered to have the least sway.

Finally, respondents suggested that the best way to encourage Year 10 students to take up senior science is to increase the relevance, engagement and interest of science lessons in junior classes. Strategies included establishing closer links between lesson content and real world contexts, and increasing the amount of quality practical work. Many teachers also suggested that developing closer links between students and real scientists and scientific endeavours would motivate students to continue with science study.

Chapter 4 : Year 10 students' perceptions of school science

Introduction

This chapter presents results from sections of the Year 10 student survey concerned with students' attitudes to, and perceptions about, school science. Specifically, the results relate to seven research questions:

S1. What are Year 10 students' attitudes towards school science?

S2. Do students like school science better than other school subjects?

S3. At what stage of schooling do students most enjoy learning science?

S4. Do Year 10 students think that school science helps them make sense of the world?

S5. Does what students learn in science make them feel pessimistic (negative) about the future?

S6. Are students' perceptions of their academic ability in science associated with personal or school characteristics?

S7. What would Year 10 students change about high school science to encourage more students to choose science in Year 11?

S1: What are Year 10 students' attitudes towards school science?

Students' enjoyment of and interest in school science were investigated using the ten 'Enjoyment of Science Lessons' items from the Test of Science Related Attitudes (TOSRA) instrument (see Appendix 2). Respondents were asked to rate their levels of agreement with five positively worded and five negatively worded statements about school science on a five point Likert scale. Responses to individual items were analysed by coding and calculating the item means and standard errors. Responses to the scale as a whole were analysed by coding and reverse scoring the negatively worded items, calculating scale means and comparing these using a series of

ANOVAs across the sample variables, also checking for interaction effects between sex, school type and school sector.

Students' responses to individual TOSRA items

The mean responses of students to the individual TOSRA enjoyment items are shown in Figure 4.1. Mean responses above the scale mid-point (3.0) indicate mean agreement with particular items, while mean responses below the mid-point indicate disagreement.

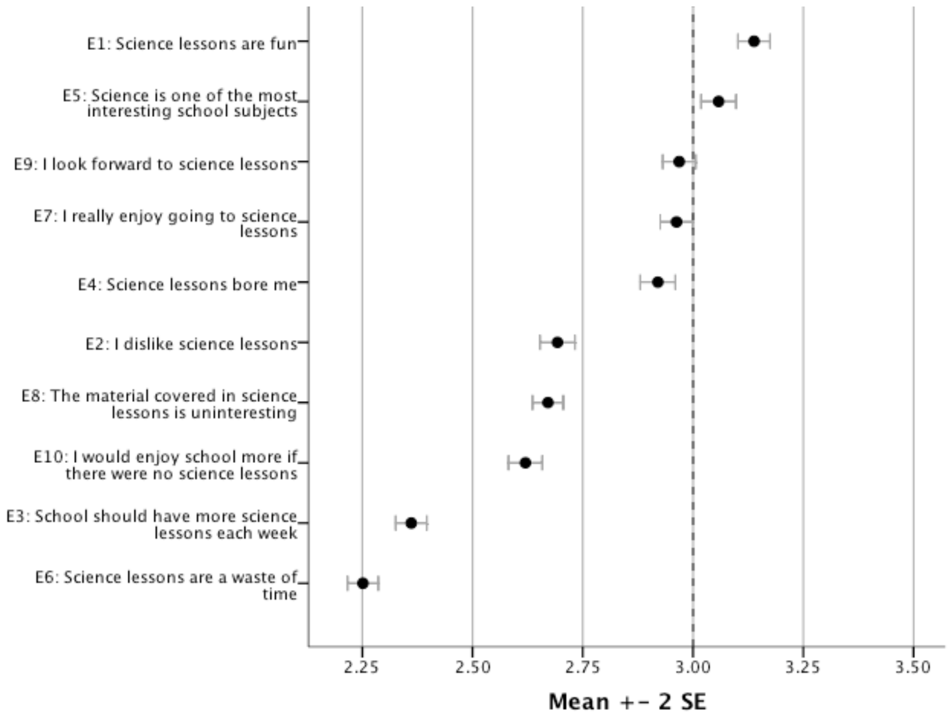

Figure 4.1: Means and standard errors of students' agreement with TOSRA statements concerning Enjoyment of Science. [Response scale = 1 (Strongly disagree); 2 (Disagree); 3 (Unsure); 4 (Agree) and 5 (Strongly agree)].

As shown by Figure 4.1, the students were generally more positive than negative about their experiences of school science. They were most inclined to agree with the statements that science lessons are fun, and that science is one of the most interesting school subjects. Students expressed the least agreement with the statement that science lessons are a waste of time and that there should be more science lessons each week.

These results are depicted in more detail in Figure 4.2, which shows the percentage breakdown of respondents for each of the agreement points for the ten items.

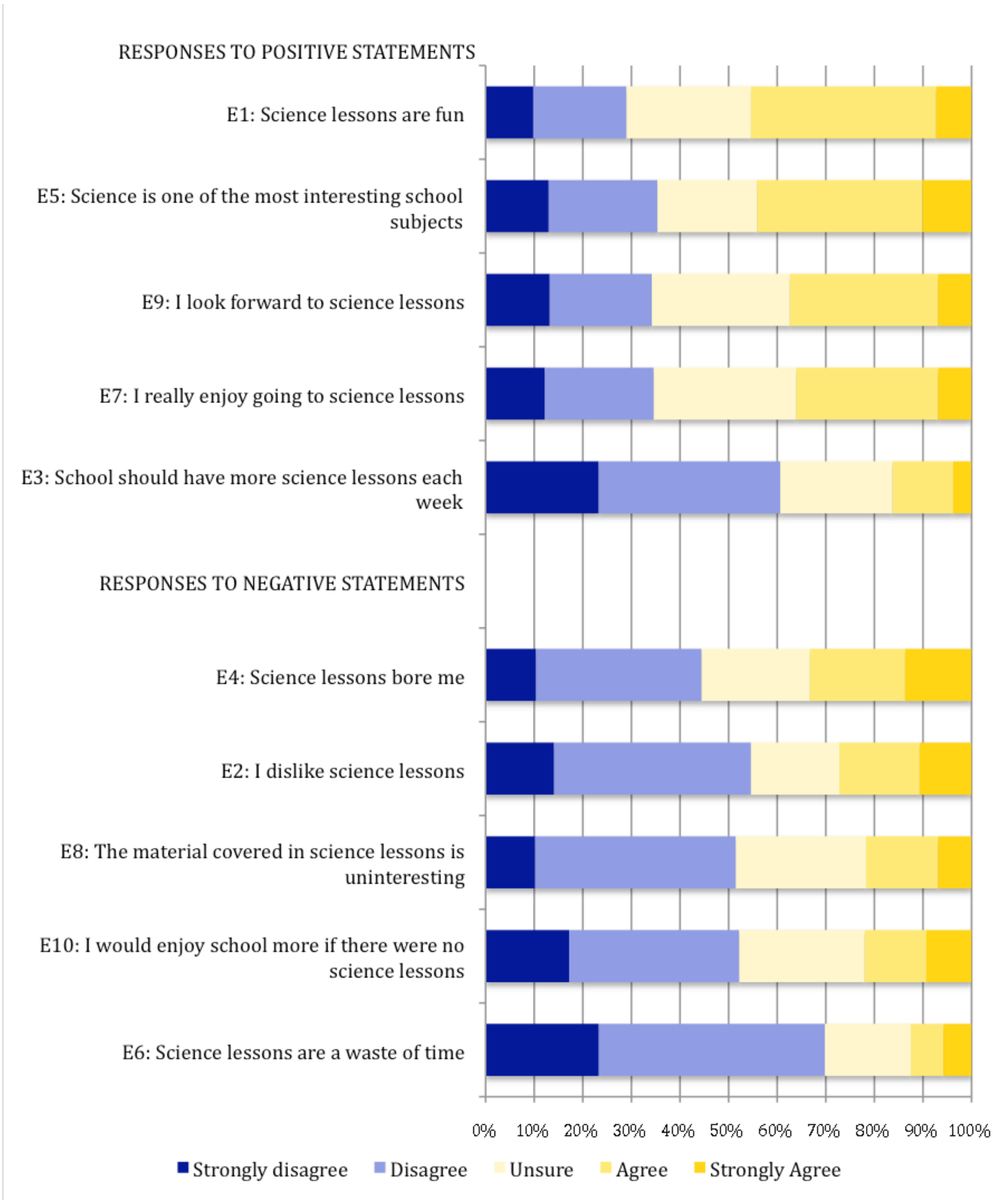

Figure 4.2: Percentage breakdown of student agreement with TOSRA statements on enjoyment of school science.

As shown in Figure 4.2, around 45% of respondents agreed or strongly agreed with the two most strongly endorsed statements: that science lessons are fun and that science is one of the most interesting school subjects. On the other hand, only 15% agreed that there should be more science lessons each week. Figure 4.2 also shows that around 36% of respondents look forward to science lessons though about 34% of students do not. Around a third of respondents agreed or strongly agreed that they found science lessons boring.

Comparisons of TOSRA scale means

The comparison of means for the entire TOSRA Enjoyment of Science Lessons scale across the sample variables showed no meaningful significant difference across sex, school type or sectors. Nor were there any interaction effects between these variables. There were, however, small but significant differences between some categories within the location[1] and state/territory[2] variables. These are described below.

Location differences

The mean enjoyment of science, as measured by the TOSRA scale, for the different location categories is shown in Figure 4.3. Mean responses above the scale mid-point (3.0) indicate a mean agreement, while mean responses below the mid-point indicate disagreement with particular items.

Post hoc comparisons of means within the different locations showed that the mean enjoyment of science was significantly less for the small rural location group in comparison to the other three location categories, as illustrated in Figure 4.3.

State/territory differences

The mean enjoyment of science, as measured by the TOSRA scale, for the different states and territories is shown in Figure 4.4. Mean responses above the scale mid-point (3.0) indicate a mean agreement, while mean responses below the mid-point indicate disagreement with particular items. Post hoc comparisons of means within the different states/territories (with equal variances not assumed) showed that the mean enjoyment of science in SA was significantly less than for NSW, QLD and VIC, but not significantly different from NT, TAS, WA or ACT, as depicted in Figure 4.4. There were no meaningful significant differences between the other states.

[1] $F(3,3755) = 13.91$, $p. < 0.001$, $\eta p2 = 0.01$
[2] $F(7,3750) = 7.277$, $p. < 0.001$, $\eta p2 = 0.01$

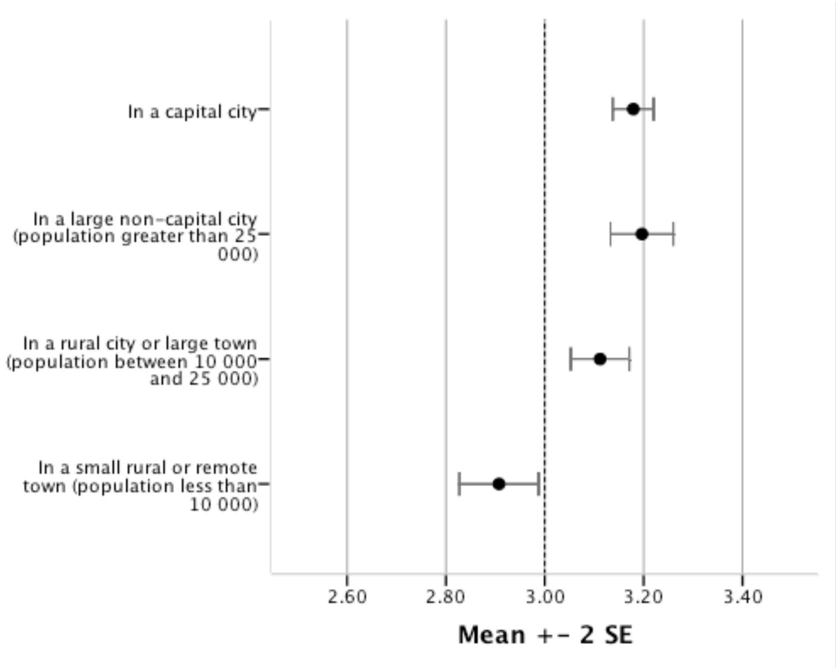

Figure 4.3: Means of responses to TOSRA enjoyment scale across different locations. [Response scale = 1 (Strongly disagree); 2 (Disagree); 3 (Unsure); 4 (Agree) and 5 (Strongly agree)].

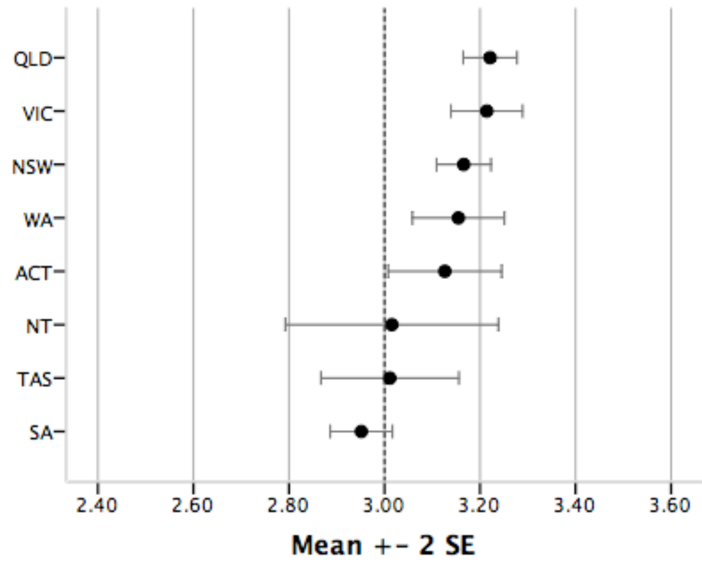

Figure 4.4: Means of responses to TOSRA enjoyment scale across different states/territories. [Response scale = 1 (Strongly disagree); 2 (Disagree); 3 (Unsure); 4 (Agree) and 5 (Strongly agree)].

In summary, the main findings emerging in relation to the question of students' enjoyment of science are more positive than negative. The results show that students were more likely to agree that science is fun and interesting, though the finding that a third of students consider science lessons boring should be cause for concern. Results differed little between boys and girls, between students attending different school types and across school sectors. Rural and remote students reported enjoying science less than students in the other three location categories, as did students studying in SA when compared to NSW, VIC and QLD. These differences were significant though small.

S2: Do Year 10 students like science better than other school subjects?

Analysis of responses to this question showed meaningful significant differences across sex and location variables. Therefore responses are summarised initially in two figures broken down by sex, and then in a figure showing location differences.

Sex differences

The means and standard errors for student responses to the question "I like school science better than most other school subjects", broken down by sex, are shown in Figure 4.5. Mean responses above the scale mid-point (3.0) indicate mean agreement with particular items, while mean responses below the mid-point indicate disagreement.

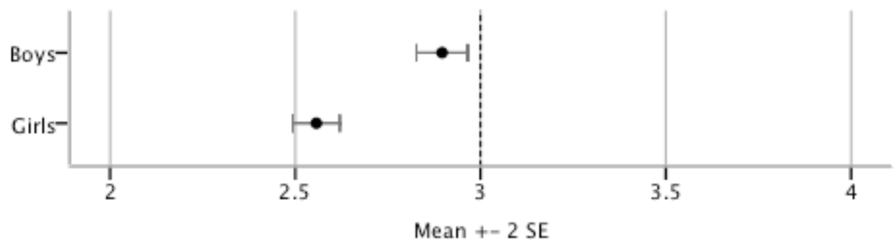

Figure 4.5: Means of responses to the item "I like school science better than most other school subjects" for boys and girls. [Response scale = 1 (disagree) through to 5 (agree)].

As shown in Figure 4.5, the mean response of both boys and girls to this statement was towards the disagreement end of the response scale. On average, students did not like science more than other school subjects. The mean response of boys was slightly but significantly higher than girls[3], suggesting boys had a greater tendency to prefer science to other subjects than did girls.

The more detailed picture behind this result is shown in Figure 4.6, which illustrates the breakdown of frequencies of responses by sex.

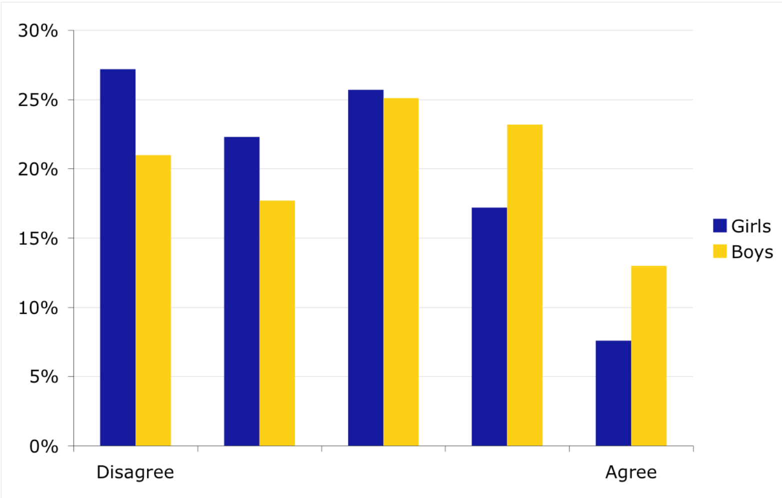

Figure 4.6: Frequencies of student responses to the question "I like school science better than most other subjects?" broken down by sex. [Response scale = 1 (disagree) through to 5 (agree)].

Figure 4.6 shows that close to 45% of students disagreed with this statement, (strongly disagree and disagree responses), suggesting that they liked science equally or less well than other subjects. Nonetheless, around a third (30%) of the students agreed that they liked science better than most other subjects (strongly agree and agree responses), and about a quarter of the sample (25%) was unsure. As suggested by the significant difference in mean responses between boys and girls, girls agreed with this statement significantly less frequently than boys, and disagreed more frequently[4].

Location differences

The means and standard errors for student responses to the question "I like school science better than most other subjects?" across the four different location categories

[3] Wilks' lambda = 0.972, $F(4,2989) = 21.74$, $p. < 0.001$, $\eta p2 = 0.03$ (12 multivariate outliers deleted from analysis). Univariate $F = 58.92$, $p. < 0.001$, $\eta p2 = 0.02$.
[4] $\chi 2\ (4) = 55.58$; $p<0.001$; Cramer's V = 0.14

are shown in Figure 4.7. Mean responses above the scale mid-point (3.0) indicate mean agreement with particular items, while mean responses below the mid-point indicate disagreement.

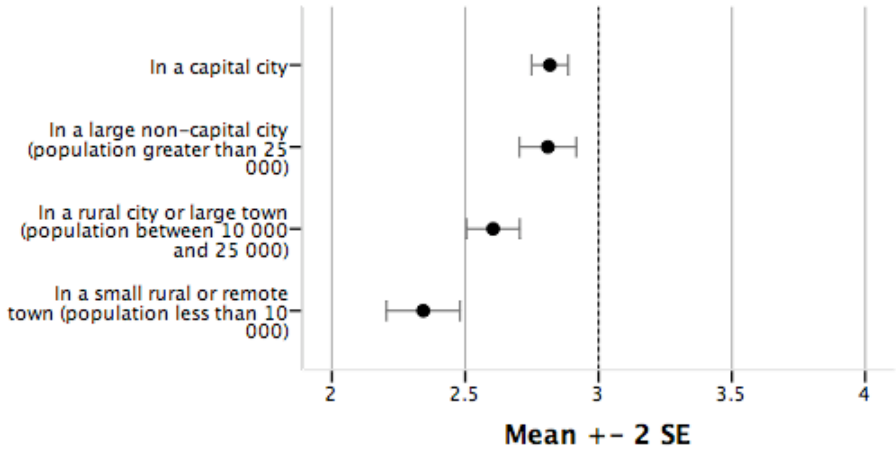

Figure 4.7: Means of responses to the item "I like school science better than most other school subjects" for four location categories [Response scale = 1 (disagree) through to 5 (agree)].

A decreasing trend from metropolitan to rural or remote students is apparent in this figure. Post hoc comparisons of means across the four location categories showed that the mean response from students in small rural or remote towns was significantly less than from students in capital cities or large non-capital cities, though this was a small effect[5]. There was no meaningful significant difference between the means of the other three location categories (capital cities, large non-capital cities, rural cities/large towns).

The more detailed picture behind this result is shown in Figure 4.8, which illustrates the breakdown of frequencies of responses to this item by location.

[5] Wilks' lambda = 0.045, F (4,3002) =16066.53, p. <0.001, ηp2 = 0.009 (12 multivariate outliers deleted from analysis). Univariate F = 14.41, p<.001, ηp2 = 0.01.

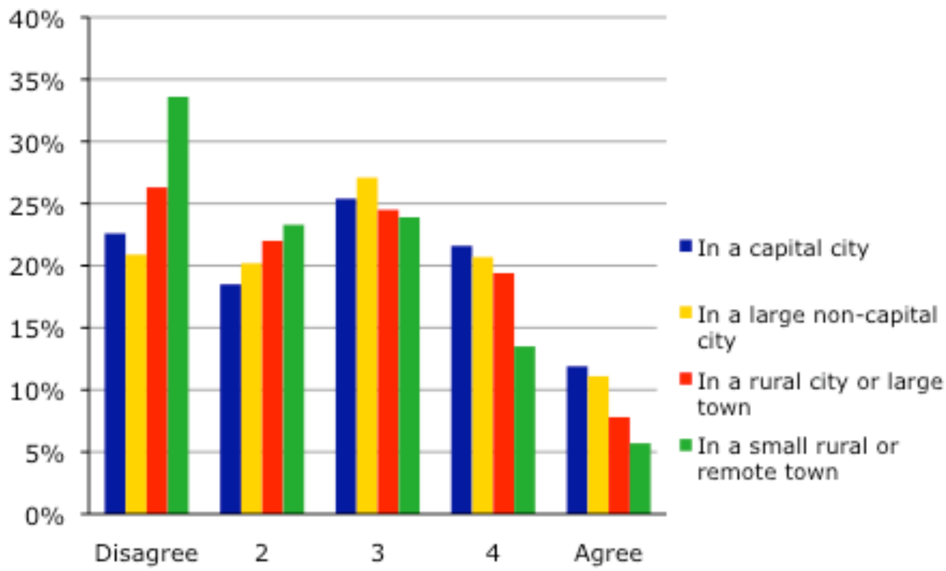

Figure 4.8: Frequencies of student responses to the question "I like school science better than most other subjects?" broken down by location. [Response scale = 1 (disagree) through to 5 (agree)].

As shown by Figure 4.8, and as suggested by the significant difference in mean responses between the location categories, students in rural and remote towns agreed less frequently than other students that they liked school science better than most other subjects. This difference contributed to a small significant difference in the frequency of responses to this item from the different location categories. [6]

In summary, students' responses to the question "I like school science better than most other school subjects" showed an average response of slight disagreement, although a substantial proportion of the sample (30%) agreed with this statement to some extent. Boys agreed significantly more than girls, and students in rural or remote locations agreed with the statement slightly but significantly less than their counterparts in large cities.

[6] $\chi 2$ (12) = 46.33; p<0.001; Cramer's V = 0.07

S3: At what stage of schooling do students most enjoy learning science?

Students responded to the item "At what stage of your schooling did you *most* enjoy learning science? Student responses to this item were analysed by crosstabulating categories with sample variables, in conjunction with standard chi-squared contingency table tests. There were no meaningful significant differences across sex, location, sector or state variables for this issue. Students' responses to this item are depicted in Figure 4.9.

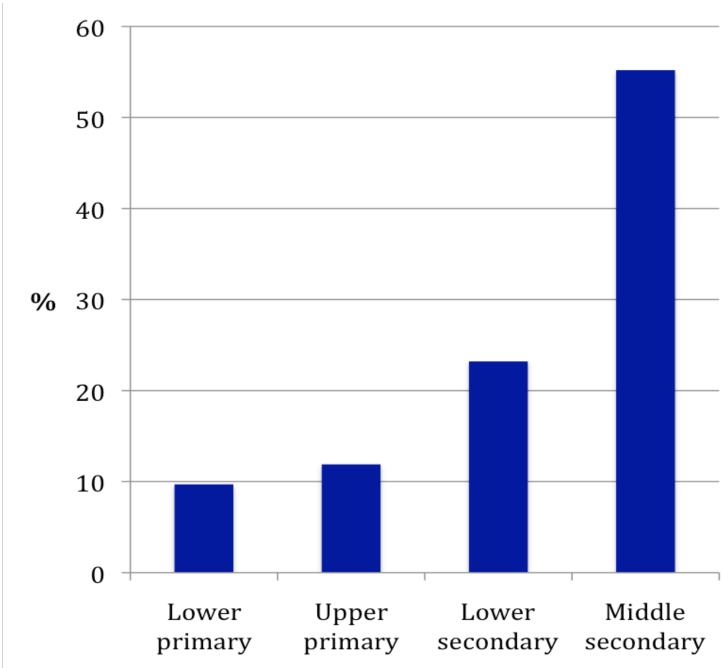

Figure 4.9: Frequencies of student responses to the question "in which stage of your schooling did you most enjoy learning science?"

Figure 4.9 shows that around 78% of students reported enjoying science the most in secondary school, with more than 55% claiming they enjoyed it most in middle secondary (Yrs 9 & 10). This result challenges findings from other studies conducted in Australia and elsewhere, and is discussed in more detail at the end of the chapter.

S4: Do Year 10 students think that school science helps them make sense of the world?

Analysis of responses to this question showed meaningful significant differences across sex of respondents. Responses are therefore summarised in two figures broken down by sex.

Sex differences

The means and standard errors for student responses to the item "What I learn in science helps me to make sense of the world" for boys and girls, are shown in Figure 4.10. Mean responses above the scale mid-point (3.0) indicate mean agreement with particular items, while mean responses below the mid-point indicate disagreement.

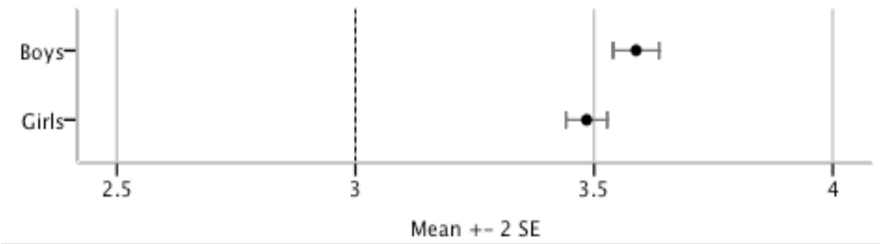

Figure 4.10: Means of responses to the item "What I learn in science helps me to make sense of the world". [Response scale = 1 (Strongly disagree); 2 (Disagree); 3 (Unsure); 4 (Agree) and 5 (Strongly agree)].

As shown in Figure 4.10, the mean response of both boys and girls to this statement was towards the agreement end of the response scale indicating that on average, students believed that science did help them to make sense of the world. The mean response of boys was slightly but significantly higher than girls[7].

The more detailed picture behind this result is shown in Figure 4.11, which illustrates the breakdown of frequencies of responses by sex. Around 62% of the students agreed that science "helped them make sense of the world", while only 16% disagreed with this assertion. Girls disagreed or were unsure of their response to this statement more

[7] Wilks' lambda = 0.972, $F(4,2989) = 21.74$, $p < 0.001$, $\eta p2 = 0.03$ (12 multivariate outliers deleted from analysis). Univariate $F = 33.64$, $p < 0.001$, $\eta p2 = 0.01$

frequently than boys, while boys strongly agreed more frequently than girls, though the differences in frequency data were very small.[8]

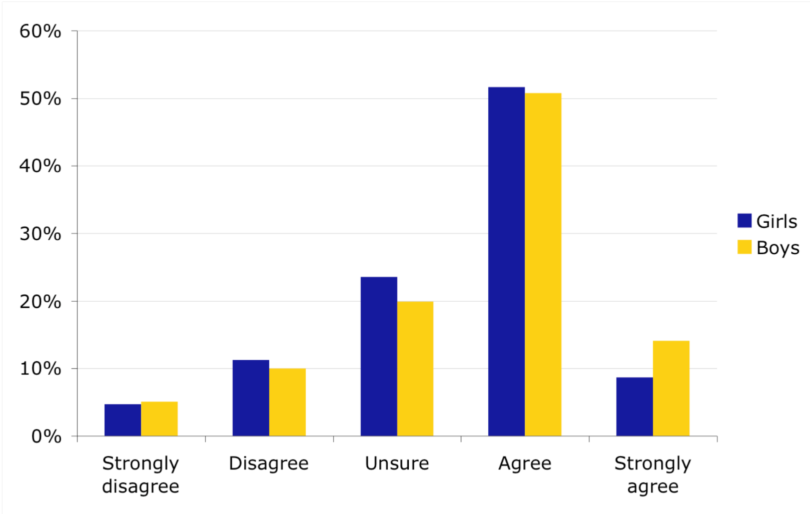

Figure 4.11: Student responses to the item "What I learn in school science helps me to make sense of the world". [Response scale = 1 (Strongly disagree); 2 (Disagree); 3 (Unsure); 4 (Agree) and 5 (Strongly agree)].

In summary, the majority of students thought that science did help them make sense of the world, and this belief was stronger among boys. There were no other meaningful significant differences for this item across other sample variables.

S5: Does what students learn in science make them feel pessimistic about the future?

Analysis of responses to this question showed no meaningful significant differences across sample variables. Responses of students to this question are summarised in two figures, broken down by sex for reasons of consistency with previous figures.

The means and standard errors for student responses are shown in Figure 4.12. Mean responses above the scale mid-point (3.0) indicate mean agreement with particular items, while mean responses below the mid-point indicate disagreement.

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[8] $\chi 2$ (4) = 31.52; $p<0.001$; Cramer's V = 0.09

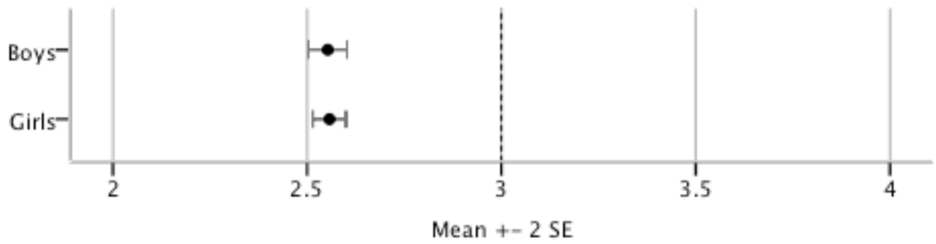

Figure 4.12: Means of responses to the item "What I learn in science makes me feel pessimistic (negative) about the future" [Response scale = 1 (Strongly disagree); 2 (Disagree); 3 (Unsure); 4 (Agree) and 5 (Strongly agree)].

As shown in Figure 4.12, the mean response to this item was slight disagreement, for both girls and boys. Students, on average, did not perceive that school science made them feel pessimistic about the future.

The more detailed picture behind this result is shown in Figure 4.13, which illustrates the breakdown of frequencies of responses by sex. The figure shows that about 17% of students reported that school science made them feel pessimistic about the future, a third of the cohort was unsure of this, and about half the students (53%) disagreed that science made them feel pessimistic about the future. The frequency differences between girls and boys were not significant to any meaningful extent, which is consistent with the non-significant comparison of means in Figure 4.12.

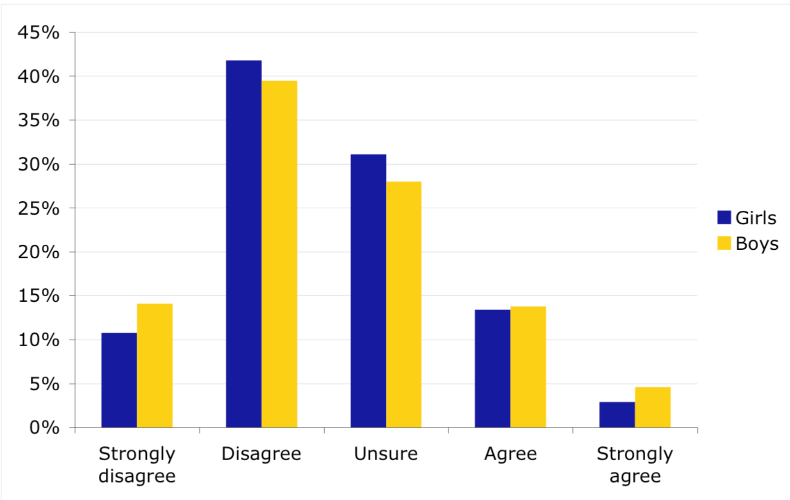

Figure 4.13: Frequencies of student responses to the item "What I learn in school science makes me feel pessimistic (negative) about the future". [Response scale = 1 (Strongly disagree); 2 (Disagree); 3 (Unsure); 4 (Agree) and 5 (Strongly agree)].

In summary, although a minority of students did find that school science made them feel pessimistic towards the future, most did not, and there was no difference in perceptions of boys and girls or across the other sample variables.

S6: Are students' perceptions of their academic ability in science associated with personal or school characteristics?

Students were asked to rate their own academic ability in science compared to others in their class. The purpose of this item was to investigate associations between self-rated academic ability, enrolment decisions and other variables. The MANOVA of students' responses to this item showed significant differences across sex, and sex by school type (co-educational and single sex). Responses of students to this question are summarised initially in two figures, broken down by sex, and subsequently in figures showing the relationship between self-rated ability for boys and girls across the different school types.

Sex

The means and standard errors for students' self-rated science ability are shown in Figure 4.14.

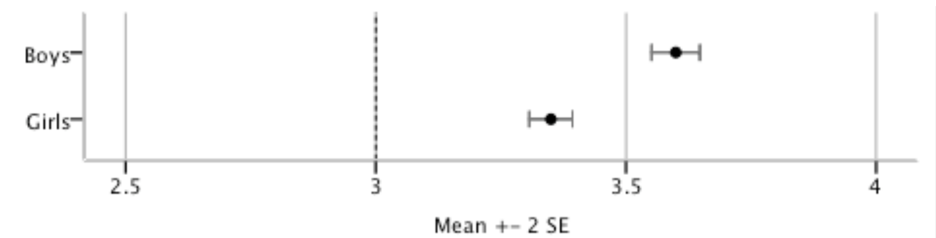

Figure 4.14: Means of responses to the item "How would you rate your own academic ability in science this year compared to others in your class?" [Response scale = 1 (Far below average); 2 (Below average); 3 (Average); 4 (Better than average) and 5 (Much better than average)].

As shown in Figure 4.14, the mean response of the whole sample of students was around 3.5, somewhere between Average and Better than average self-rated ability.

The mean self-rating in science for boys was significantly higher than for girls.[9] Boys, on the whole, perceived themselves as more able than did girls.

This difference in mean self-reported academic ability of boys and girls is depicted in more detail in Figure 4.15 below.

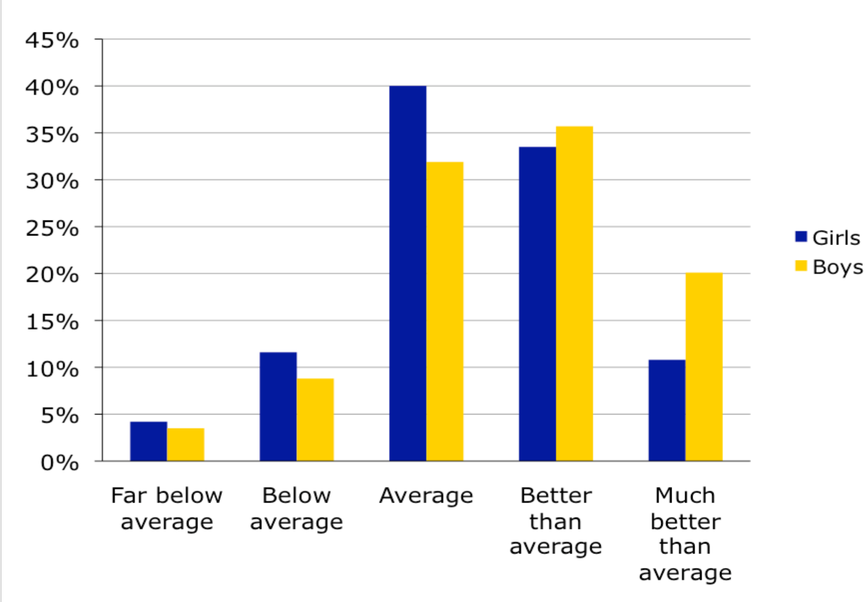

Figure 4.15: Percentage of respondents across categories of self-rated academic ability, for boys and girls. [Response scale = 1 (Far below average); 2 (Below average); 3 (Average); 4 (Better than average) and 5 (Much better than average)].

Overall, about half of the respondents rated their ability in science above average compared to others in their class, while around 14% rated their ability below average. Proportionately more boys reported having better or much better than average ability, and more girls reported average, below average or far below average ability in science[10] (Figure 4.15). In particular, the percentage of boys reporting "much better than average" ability was double that of girls. These differences contributed to the mean reported science ability being significantly lower for girls than boys.

Sex by school type

Results for students' reported ability in science were explored separately for girls and boys in single sex and co-educational schools, which showed a significant sex by

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[9] Wilks' lambda = 0.972, $F(4,2989) = 21.74$, $p. < 0.001$, $\eta p2 = 0.03$ (12 multivariate outliers deleted from analysis). Univariate $F = 69.7$, $p. < 0.001$, $\eta p2 = 0.02$

[10] $\chi 2\ (4) = 79.47$; $p < 0.001$; Cramer's V = 0.15

school type effect[11]. Although the effect size was extremely small (0.006), this finding was supported by non-parametric tests that showed an effect size within the 'small' range adopted in this report. The interaction between these two variables is shown in Figure 4.16.

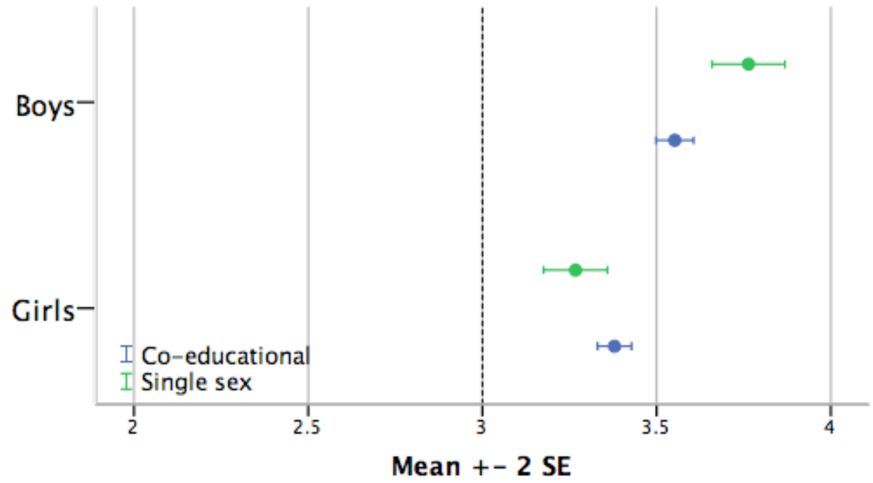

Figure 4.16 . Means of responses to the item "How would you rate your own academic ability in science this year compared to others in your class?" broken down by sex, across school types (single sex and co-educational. [Response scale = 1 (Far below average); 2 (Below average); 3 (Average); 4 (Better than average) and 5 (Much better than average)].

As shown in Figure 4.16, the mean self-reported ability for boys was significantly higher in single sex than co-educational schools. In the case of girls, however, the mean for single sex schools was lower than for coeducational schools, although this difference between the two school types was not significant at the 0.001 level of significance. The more detailed pictures relating to this relationship are shown in Figure 4.17 and Figure 4.18.

As is indicated in these figures, beginning with the Average response point, students of both sexes reported their science ability as average more frequently if they went to co-educational schools, and less frequently if they went to single sex schools. However, the direction of the departures from the average for self-reported ability in single-sex schools is different for boys and girls.

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[11] Wilks' lambda = 0.993, $F(4,2989) = 5.56$, $p. < 0.001$, $\eta p2 = 0.007$ (12 multivariate outliers deleted from analysis). Univariate $F = 18.71$, $p. < 0.001$, $\eta p2 = 0.006$

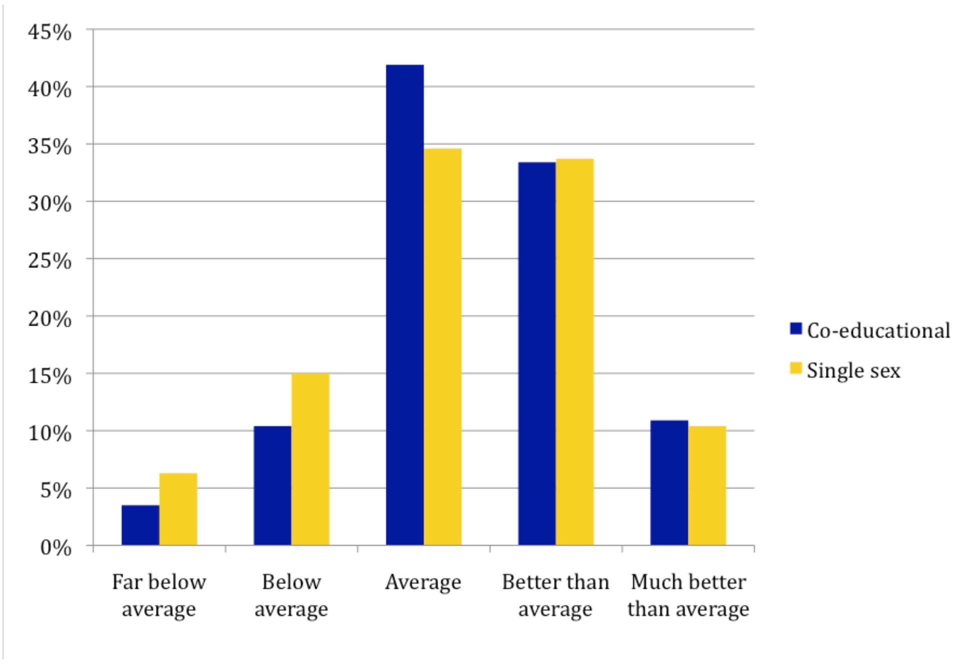


Figure 4.17: Girls' self rated ability in science, for students attending coeducational (n=1474) and single sex (n= 520) schools. [Response scale = 1 (Far below average); 2 (Below average); 3 (Average); 4 (Better than average) and 5 (Much better than average)].

Figure 4.17 shows the distribution of responses for girls, which chi-square tests suggested were significantly different than would be expected were there no association between self-reported ability and school type[12]. Proportionately more girls from single sex schools rate themselves as "Below" or "Far below average", although there is only a suggestive significant difference for this specific finding.[13]

Conversely, Figure 4.18 below shows that proportionately more boys from single sex schools rated themselves as "Much better than average", and this difference is more than would be expected were there no association between school type and self-rated science ability[14].

[12] Girls $\chi2$ (4) = 19.84; p=0.001; Cramer's V = 0.10:
[13] ASR = -2.8 ($0.001<p<0.01$)
[14] Boys $\chi2$ (4) = 19.85; p=0.001; Cramer's V = 0.10, ASR = 4.0, ($p<0.001$).

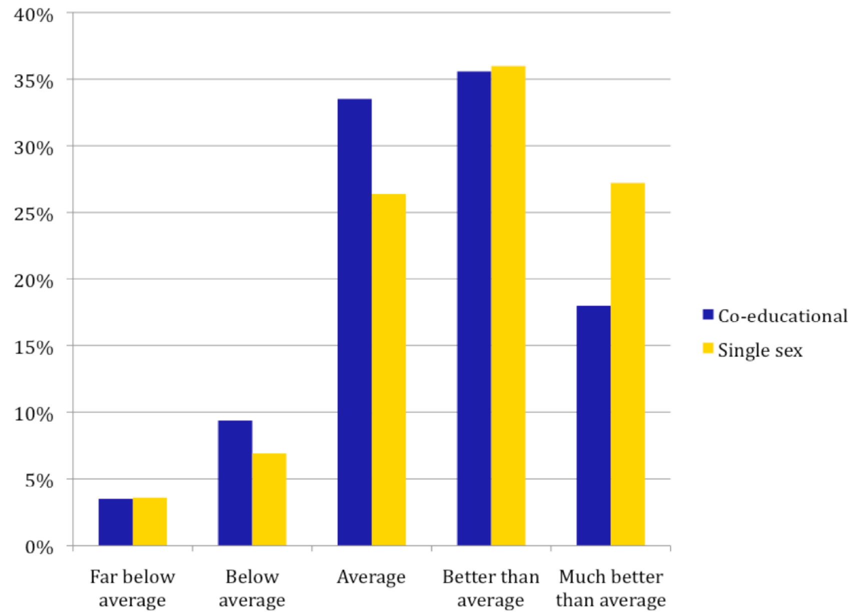


Figure 4.18: Boys' self rated ability in science, for students attending coeducational (n=1371) and single sex (n=394) schools. [Response scale = 1 (Far below average); 2 (Below average); 3 (Average); 4 (Better than average) and 5 (Much better than average)].

In summary, the mean self-rated ability in science was between Average and Better than average for both girls and boys. The mean perceived ability in science for boys was significantly higher than for girls. Boys, on the whole, perceived themselves as more able than did girls. In addition, there was evidence suggesting that while boys in single sex schools have a more positive view of their science ability in relation to their classmates than boys in co-educational schools, this was not the case for girls in single sex schools.

S7: What would Year 10 students change about high school science to encourage more students to choose science in Year 11?

Students provided written answers to the question "If you could change one thing about high school science to encourage more students to choose it in Year 11, what would you change?" The responses were coded and grouped into themes using constant comparative analysis. The frequency of each of the themes and subthemes raised by the respondents is shown in Figure 4.19.

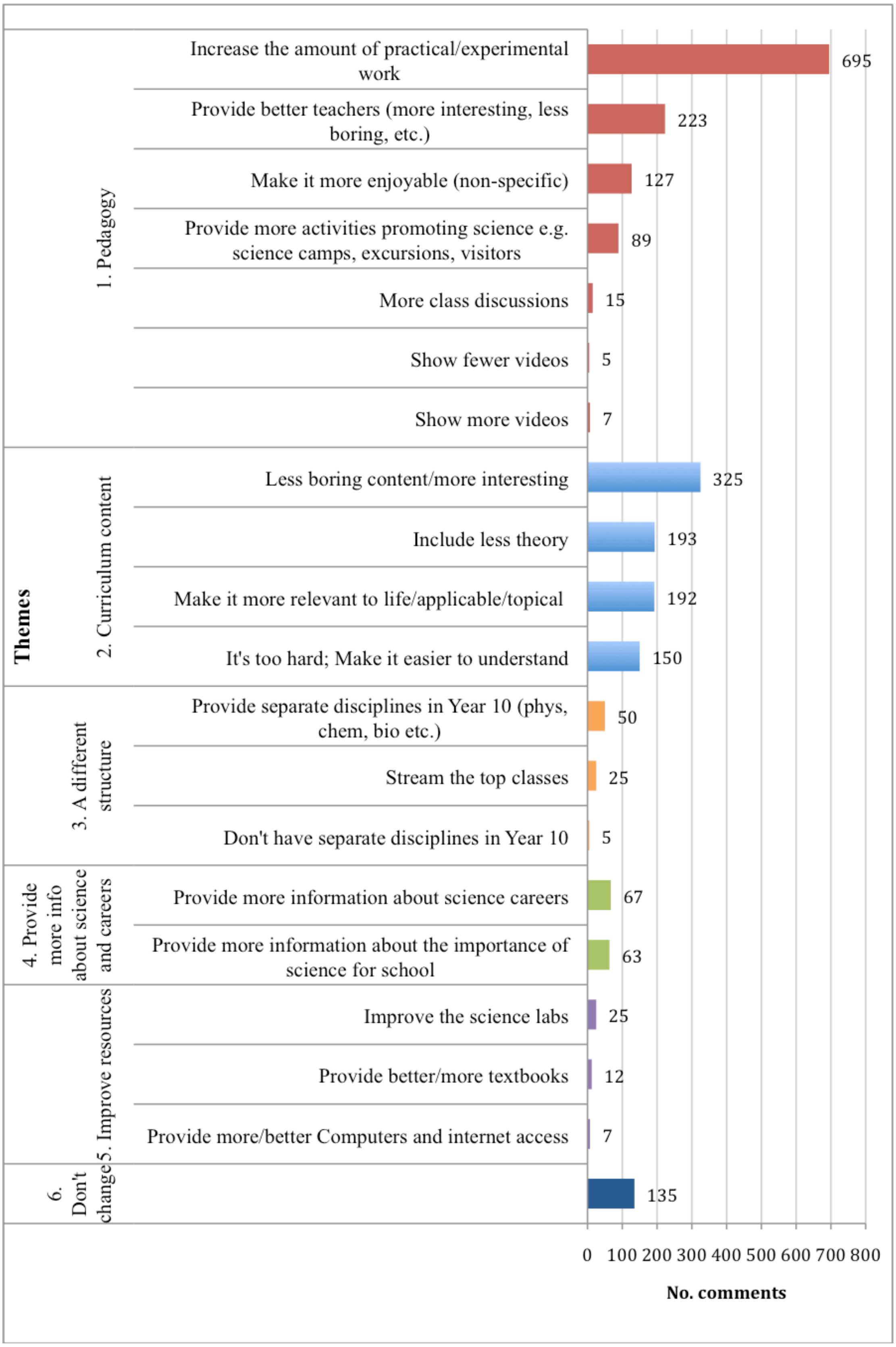


Figure 4.19: Frequency of students' recommendations in response to the question: 'If you could change one thing about high school science to encourage more students to choose it in Year 11, what would you change?' (N=2414 recommendations from 1938 students).

Figure 4.19 shows that students were most inclined to recommend increasing the amount of practical/experimental work conducted in science classes. This comment was expressed more than twice as frequently as the next most common recommendation. The figure also reveals a concern about making school science more interesting (or less boring) and relevant - a recommendation also strongly made by teachers in Phase One. In contrast to the emphasis on pedagogy and curriculum, few students seemed to consider improved facilities or resources as instrumental in increasing participation.

Conclusion

The previous chapter reported that around 43% of science teachers considered students' negative experiences in junior science classrooms to have been very influential or extremely influential in enrolment declines. Just over half attributed similar levels of influence to declines in student interest in science. This chapter reported findings from sections of the Year 10 student survey concerned with students' perceptions of their own interest in, and enjoyment of, science.

The concept of 'enjoyment of science' is multifaceted, and the student survey investigated a range of indicators. Around 45% of respondents agreed that science lessons are fun, with about 37% agreeing that they really enjoyed going to science lessons. On the other hand, about 28% disliked science lessons and a third found them boring. Respondents from South Australia reported significantly lower levels of enjoyment than did their peers in Queensland, NSW and Victoria.

In terms of comparisons with other school subjects, around 44% of respondents agreed that science was one of the most interesting school subjects, although only 30% agreed that they preferred school science to most other subjects. Boys were significantly more likely than girls to prefer science to other subjects, while students in small rural or remote towns were significantly less inclined than those in larger centres to prefer science.

Around 78% of students reported enjoying science more in secondary school than in primary school, with more than 55% claiming they enjoyed it more during the previous two years (Years 9 & 10) than at any other stage of their schooling. This result is in contrast to findings from other studies, which reported that students' attitudes to school science tend to decline over the first three or four years of secondary school (e.g. Bennett & Hogarth, 2009; Speering & Rennie, 1996). This difference may be due to the fact that *Choosing Science* surveyed the retrospective opinions of students, whereas most studies reporting less enjoyment in lower secondary were either cross-sectional or longitudinal in design. Thus, students' responses may be influenced by the recency of their middle school experiences, as opposed to the more distant memories of primary schooling. This raises questions of whether the results of attitudinal research are dependent on when students are asked, and which perspective - cross-sectional or retrospective - is most relevant in terms of students' enrolment decisions.

In terms of the usefulness of school science, around 63% of students agreed or strongly agreed that it helped them make sense of the world. Of the remainder, 22% were unsure while 16% disagreed or strongly disagreed with this statement. Boys were significantly more inclined than girls to agree with this statement.

Phase One teachers generally disagreed with the proposition that science enrolment declines were due to student perceptions that science can have a negative impact on society. Their views were supported by results from the student survey, with only 17% of respondents agreeing that school science made them feel pessimistic about the future.

Students were asked to rate their own academic ability in science compared to others in their class. Around half rated their own ability above average, though boys tended to rate their ability significantly higher than girls. This gender difference is consistent with PISA 2006 results concerning self-efficacy (Thomson & De Bortoli, 2008). Interestingly, boys in single sex schools tended to rate their ability significantly higher than did boys in coeducational schools. This pattern was not the case for girls in single sex and co-educational schools, where there was some suggestive evidence for the converse. This curious finding provides a basis for further research into the different perceptions of ability held by girls and boys in single sex and coeducational schools.

Finally, when asked for suggestions to encourage more students to take Year 11 science, Year 10 students emphasised the importance of increasing practical work. They also recommended greater relevance and applicability of science, and less theory, along with better teachers and more interesting content. Although many respondents suggested that science should be made easier, this was not suggested as frequently as comments relating to relevance, and practical/theoretical issues. In general, curriculum and pedagogy appear to be the two main areas of concern for the respondents in this study.

Chapter 5 : Students' attitudes to science: Comparisons between 1977 and 2007

Introduction

Approximately half of all science teachers surveyed in Phase One considered declines in science enrolments to have been strongly influenced by declines in the levels of interest in science among today's young people. While this view is often heard anecdotally, no research has been undertaken to determine whether this is the case. Phase Two of the *Choosing Science* study sought to investigate this proposition by comparing the attitudes of contemporary Year 10 students with those of students from an earlier period when senior science enrolments were proportionally much higher. This chapter reports and discusses the findings of this comparison.

S8: Have Year 10 students' attitudes to science and science careers declined over time?

Details of the TOSRA scale, the 1977 study and the sampling strategies are described in Chapter 2. The results below relate to scores on four TOSRA scales by a sub-set of the *Choosing Science* sample similar in size, sex and school characteristics to the 1977 cohort. The reliability, mean scores and standard deviations were calculated for the four scales after negatively worded items were reverse scored. Table 5.1 compares results from Fraser's 1977 study with those from the corresponding 2007 cohort.

Alpha reliability levels from the 2007 data were highly consistent with the 1977 results and confirm the internal reliability of the TOSRA scales. Table 5.1 shows that mean scores on the Social Implications of Science, Enjoyment of Science Lessons and Normality of Scientists scales were marginally lower among the 2007 cohort, suggesting that these students had less positive attitudes towards these dimensions of science. However, the differences were only significant (+/- 2SE) for the two latter scales. More importantly, the effect sizes (Cohen's *d*) of differences in mean scores for the three scales were only small (Cohen, 1988; Coe, 2002), indicating that the differences are unlikely to be meaningful. As a point of comparison, the differences in mean scores between the two cohorts are equivalent to the differences between those of Year 9 and Year 10 students in Fraser's 1977 study. Given the 30-year period between the two measurements it is even less likely that these effect sizes indicate educationally meaningful differences between the two groups. The results therefore do not support the contention that today's students have less positive attitudes towards science than did those in 1977.

Table 5.1: Comparisons of scale reliability, means and standard deviations from the 1977 and 2007 TOSRA studies

TOSRA Scale	Scale reliabilities, means and standard deviations for 1977 and 2007 data with associated effect size.				
	Scale α reliability 1977	Scale α reliability 2007	Mean (sd) 1977	Mean (sd) 2007	Effect size (Cohen's *d*)[15]
Social Implications of Science	0.82	0.86	37.3 (5.2)	36.0 (6.9)	0.19
Enjoyment of Science Lessons	0.93	0.93	33.5 (8.6)	31.3 (9.5)	0.23
Normality of Scientists	0.78	0.82	36.3 (4.9)	34.7 (6.6)	0.24
Career Interest in Science	0.91	0.90	28.8 (8.4)	29.1 (8.8)	-0.04

With regard to Career Interest in Science, there was very little difference between the mean scores of the two cohorts, and the effect size of any difference was negligible. This comparison provided no evidence that students' levels of interest in science careers have become less positive over time.

Comparisons with national TOSRA data

The comparison above was limited to students in the Sydney metropolitan area. Ideally, a similar longitudinal comparison between two national cohorts would have contributed further insights. Unfortunately no comparable nationwide Year 10 TOSRA surveys were conducted in the earlier period. Nevertheless, the *Choosing Science* study sought to determine, for 2007 at least, how closely the Sydney data matched the national data.

[15] Cohen's *d* was calculated using standard deviations of the 1977 means. A calculation using pooled standard deviations produced similar effect sizes.

Figure 5.1 shows the mean scores and standard errors of the two Sydney metropolitan cohorts (2007 and 1977) and the national 2007 cohort (n=3759) on each on the four TOSRA scales.

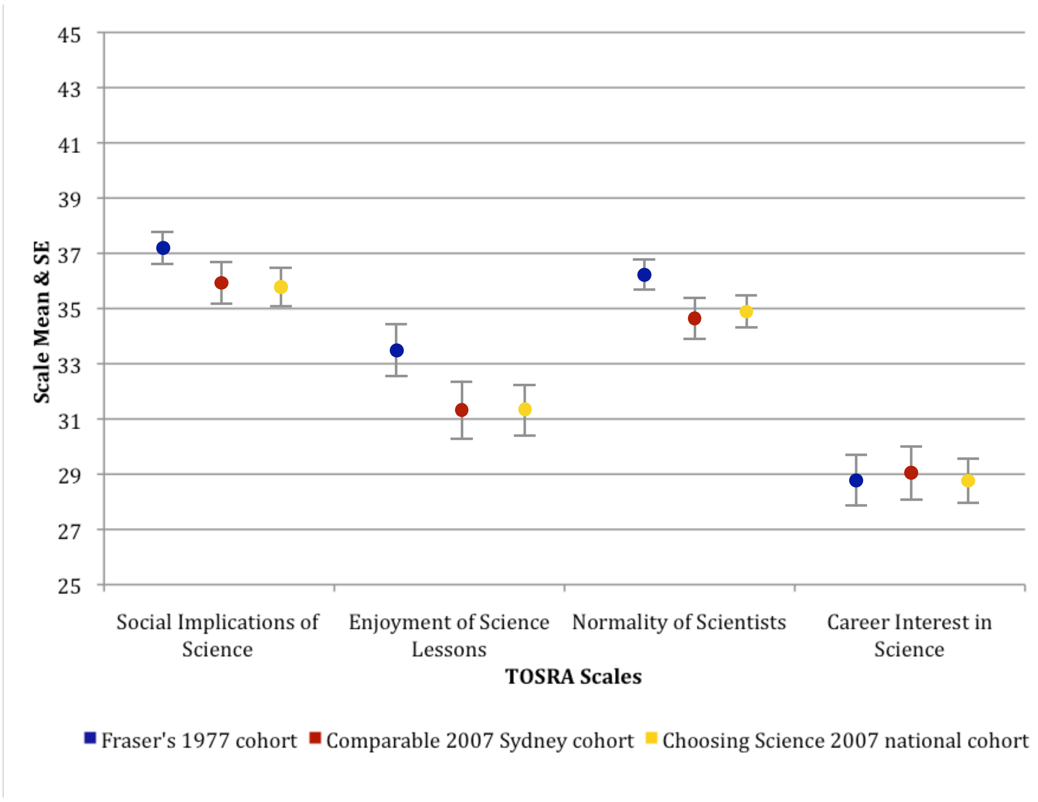


Figure 5.1: Comparison of Mean scores (+/- 2 SEs) of the three cohorts on four TOSRA scales.

It is clear from Figure 5.1 that there was very little difference between the mean ratings of the 2007 Sydney and national cohorts, suggesting that the attitudes of Sydney students are typical of the national cohort. It is tempting to speculate that this is also likely to have been the case a generation ago, but this proposition cannot be verified on the basis of these results.

Conclusion

This chapter reported on an investigation into whether students' attitudes to science and science careers have changed significantly since 1977 when science enrolments were proportionally much higher. Although based on comparisons between limited samples, the findings nonetheless challenge the proposition that declines in science enrolments have been due to corresponding declines in students' attitudes to science and science careers. While the comparison suggested that students today tend to enjoy science classes a little less than those in 1977 and are slightly less inclined to see scientists as 'normal', the effect sizes of these declines over such a long period of time are unlikely to indicate educationally meaningful differences.

The results also show that the *Choosing Science* students did not have less positive attitudes towards science careers than their predecessors. This finding gives no support to assumptions that declines in science enrolments have been due to a decrease in the level of interest in science careers among Year 10 students.

The longitudinal comparison of attitudes investigated in this chapter was the most feasible approach to investigating whether students' attitudes to science and science careers have declined over the last generation or so. Nevertheless, there were some limitations to the methodology which should be considered in interpreting the findings. First, the raw data from 1977 no longer exist (Fraser, pers. comm. 17/11/08), so comparisons could only be made with the reported results of that study. Second, there have been many demographic, social, cultural and educational changes in Australia since 1977. For example, a greater proportion of girls now choose science subjects and there are many more subject options, not to mention different science curricula and whole new fields of science such as nanotechnology. Finally, even though the study found no meaningful differences between the attitudes of students in 1977 and 2007, the findings do not establish that students' attitudes have remained stable throughout the intervening period. The influence of these limitations on the findings is a matter for discussion.

Chapter 6 : Students' decisions about Year 11 science

Introduction

A key focus of this study was the nature of Year 10 students' deliberations about whether or not to take science subjects in Year 11. This chapter presents the results of investigations into the following questions:

S9: What reasons do students give for choosing senior science subjects?

S10: Do students' reasons for choosing science vary across subject choice categories?

S11: What reasons do students give for not choosing senior science?

S12: Are students' enrolment decisions associated with their attitudes to and perceptions of science?

S13: Is there an association between students' reasons for choosing or not choosing science and their sex, school type or school sector?

S14. Which stage of schooling do students believe had the most influence on their decisions about taking senior science subjects?

S15: Which people do students consider the most influential in helping them make their decisions about choosing science?

Categorising Year 10 students' decisions about taking senior science subjects

Table 6.1 shows the frequency with which the major science subjects – physics, chemistry and biology - were chosen for Year 11, as well as the number of students choosing other science subjects or no science. The Other Science category included earth science, human biology, geology, astronomy and psychology, among others.

Table 6.1: Frequency with which subject options were chosen by students for Year 11.

	Physics	Chemistry	Biology	Other science	No science
Girls	349	623	845	344	508
Boys	658	701	486	199	400
Total	1007	1324	1331	543	908

The frequencies in Table 6.1 total more than 3759 because a number of students chose more than one science subject. Biology and chemistry were the most popular choices, while nearly a quarter of students chose not to study any science in Year 11. The frequencies of different subject choice combinations are shown in Table 6.2.

Table 6.2: Frequency of science subject combinations chosen for study in Year 11.

One science only		Two sciences		Three + sciences	
Subject choice	**Number of students**	**Subject choice**	**Number of students**	**Subject choice**	**Number of students**
physics	241	physics chemistry	424	physics chemistry biology	185
chemistry	227	physics biology	54	physics chemistry other	50
biology	555	physics other	25	chemistry biology other	51
other	231	chemistry biology	329	physics biology other	8
		chemistry other	29	physics chemistry biology other	29
		biology other	120		
Total	**1254**	**Total**	**981**	**Total**	**323**

The table shows that most students chose only one science, most commonly biology. The combinations of physics and chemistry, and chemistry and biology were the most common options for students choosing two sciences, while physics, chemistry and biology was the most popular three-science option.

Investigations of students' reasons for their science choices are often complicated by the number of combinations of science subjects they can select. For the purposes of this study, it was important not only to be able to identify students' reasons for choosing or not choosing science, but to be able to distinguish between motivations for choosing specific science subjects. It was also necessary to ensure sufficient sample sizes in each choice category, and for the categories to be independent to allow proper statistical comparisons. The questionnaire was therefore designed so that students choosing particular combinations of science subjects were directed to one of four survey subsections, comprising questions focusing specifically on physics, chemistry, biology or other science subjects. Those choosing no senior science were directed to a subsection containing questions specific to this decision.

Table 6.3 shows the mutually exclusive combinations used for analyses, choice categories and related survey subsections. The Phys+ category includes students choosing physics either as their only science or together with biology, chemistry and Other Science for Year 11. The Chem+ category includes students choosing chemistry either as their only science, or together with biology and/or Other Science. The Bio+ category includes students choosing biology either as their only science, or together with Other Science. The Other Science category includes students choosing only other sciences. These categories are used in several of the analyses reported in this Chapter.

Table 6.3: Choice categories, subject combinations and focus of questions for relevant subsections

Choice category	Possible subject combinations	Focus of questions	Category counts	
Phys+	physics only physics plus one or more additional science subject(s)	physics	Girls	349
			Boys	658
			Total	**1007**
Chem+	chemistry only chemistry plus biology and/or other science subject(s)	chemistry	Girls	362
			Boys	241
			Total	**603**
Bio+	biology only biology plus other science subject(s)	biology	Girls	461
			Boys	207
			Total	**668**
Othersci	other science subject(s) only	other science	Girls	177
			Boys	112
			Total	**289**
Nosci	No science subjects	No science	Girls	508
			Boys	400
			Total	**908**

S9: What reasons do students give for choosing senior science subjects?

Students choosing science were asked to indicate their agreement with a list of possible reasons for their decisions. Each student responded in the context of one particular science subject; that is, students in the Phys+ category indicated their reasons for choosing physics, while those in the Chem+ category indicated their reasons for choosing chemistry, and so forth. Figure 6.1 shows students' mean agreement with these reasons. The dotted line indicates the "Unsure" mid-point, with means to the right indicating increasing agreement. Results in Figure 6.1 reveal that overall, students were motivated primarily by their anticipation that their senior science subject would be interesting. The strategic benefit of taking science for university or careers received the second highest endorsement, followed by perceived ability in the subject. In general, students perceived good teachers and teacher encouragement to be the least influential of the seven reasons for choosing science covered in this set of questions.

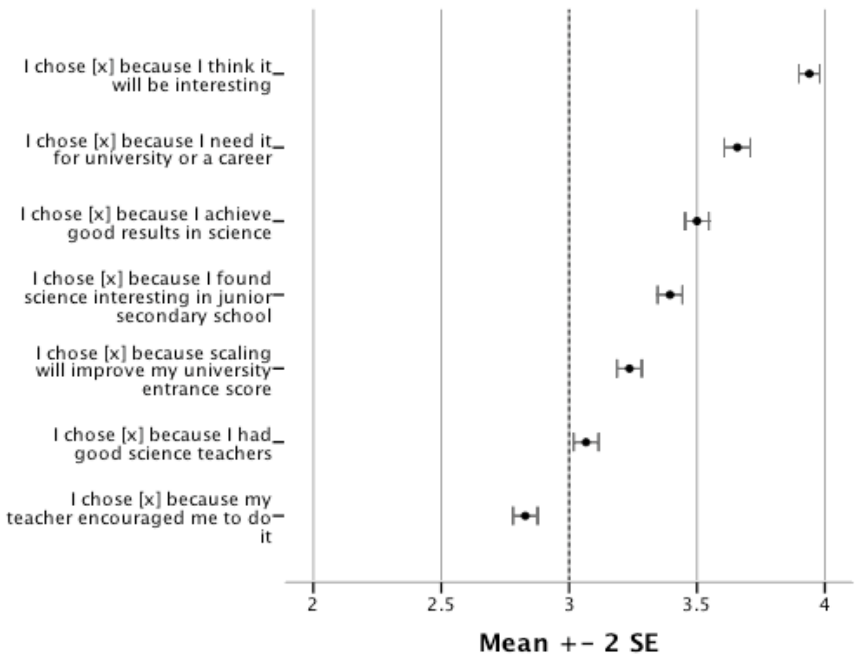


Figure 6.1: Means of Year 10 students' responses to items explaining why they chose to study science in Year 11. [Response scale: 1 = Strongly disagree, 2 = Disagree, 3 = Unsure, 4 = Agree, 5 = Strongly agree]

Figure 6.2 details the percentages of students agreeing or disagreeing with each reason.

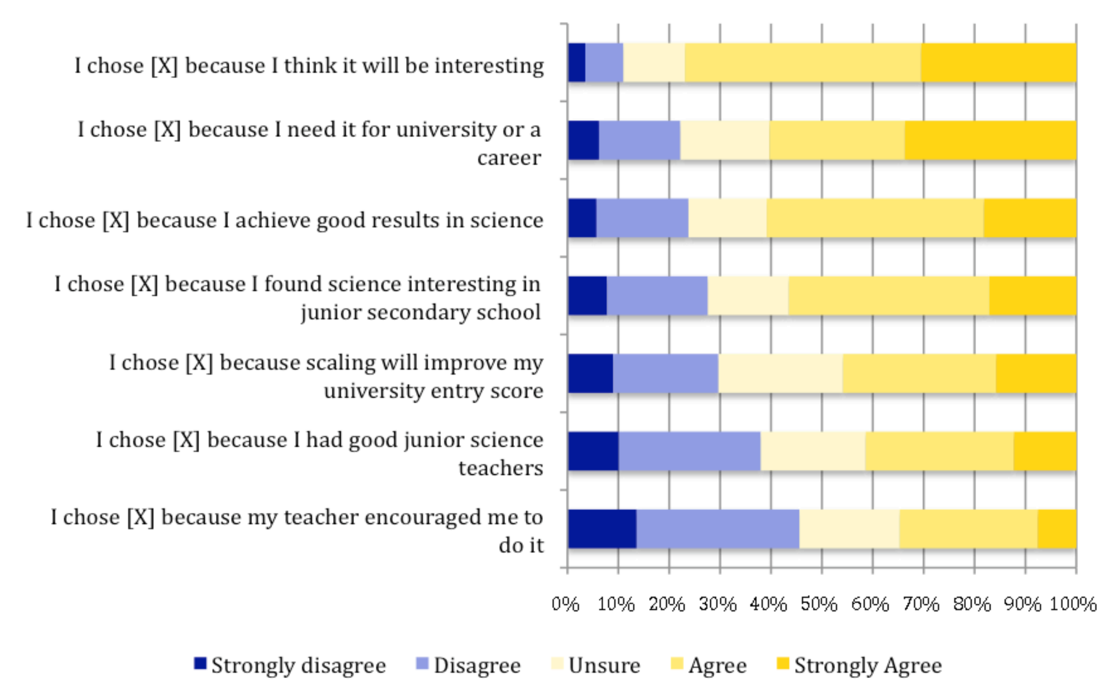


Figure 6.2: Percentage breakdown of students' responses to items explaining why they chose to study science in Year 11. [X] represents the specific science subject to which responses refer.

The figure shows that around 77% of respondents chose their science subject because they thought it would be interesting, and about 60% because they needed it for university or a career, or because they had received good results. Only 35% of students agreed that they chose their subject because of teacher encouragement, and about 40% agreed that their choice was due to good junior science teachers.

S10: Do students' reasons for choosing science vary across subject choice categories?

Students' reasons for choosing specific science subjects were compared to investigate whether different reasons were associated with different subjects. Figure 6.3 compares the mean responses of students within different subject choice categories to items asking about their reasons for choosing those subjects. The dotted lines indicate the "Unsure" mid-point, with means to the right of this indicating increasing agreement.

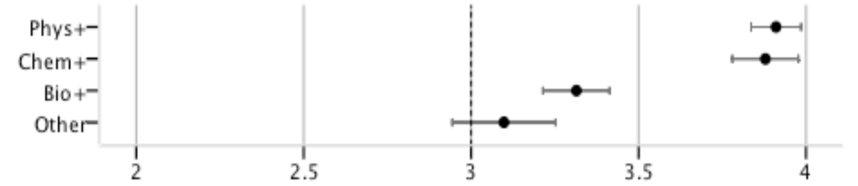
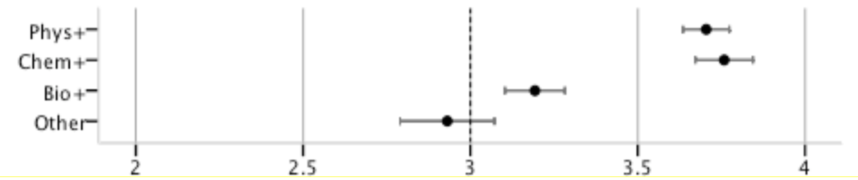
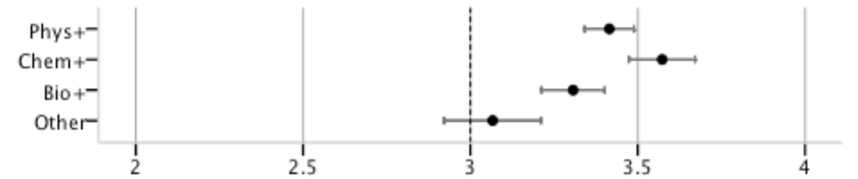
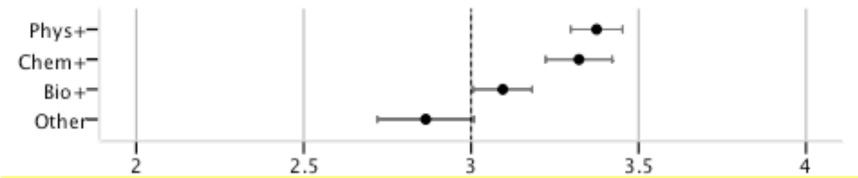
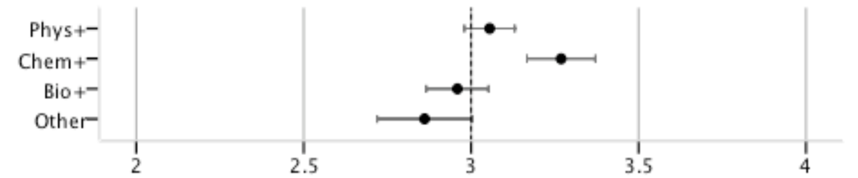
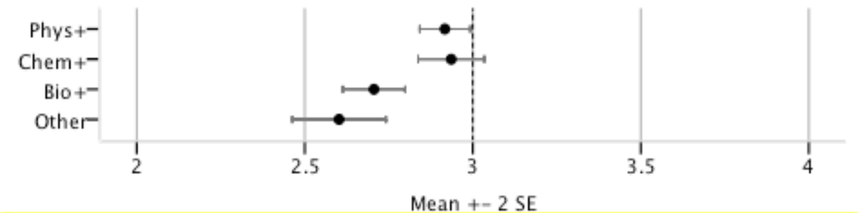
Item	Means and standard errors of items for four subject choice categories
I chose [X] because I think it will be interesting. [a]	
I chose [X] because I need it for university or a career. [b]	
I chose [X] because I achieve good results in science. [c]	
I chose [X] because I found science interesting in junior secondary school. [d]	
I chose [X] because scaling will improve my university entrance score. [e]	
I chose [X] because I had good science teachers. [f]	
I chose [X] because my teachers encouraged me to do it. [g]	

Figure 6.3: Means of Year 10 students' responses to seven items explaining why they chose to study science in Year 11, differentiated by science subject [X]. [Response scale: 1 = Strongly disagree, 2 = Disagree, 3 = Unsure, 4 = Agree, 5 = Strongly agree]

Results shown in Figure 6.3 can be read in two directions. First, for a given subject choice category, the means and error bars for each item can be compared by reading down the panels of the figure. This shows, for each of the subject choice categories, broadly similar patterns of mean values for the items as in Figure 6.1. This suggests that the order of students' reasons does not vary greatly across subject choice categories. The two items most strongly endorsed by students in each category were that science will be interesting, and that they will need it for future study or careers. Regardless of their choice of science subject, students were least inclined to agree that their decision was because of good science teachers or encouragement from teachers.

The results in Figure 6.3 can also be examined within individual items, comparing the response to each item within each of the subject choice categories. A MANOVA was conducted comparing the mean responses for each of the items in Figure 6.3 across the different choice categories. There was a meaningful and significant multivariate effect[16], and meaningful significant main effects for all items.[17]

The main findings from post hoc tests within items are that there were generally no significant differences between mean responses from students responding in the context of physics and chemistry. The means for both of these categories were generally significantly higher for most items than those in the Othersci category, with Bio+ means generally between them. Interesting exceptions are for the item 'I chose [X] because I think it will be interesting', for which the Bio+ category mean was as high as the Phys+ and Chem+ categories. For the item 'I chose [X] because I had good science teachers' the mean for the Chem+ category was significantly higher than all the other categories.

In addition, for the items 'I chose [X] because I need it for university or a career' and 'I chose [X] because I achieve good results in science', the differences between the means for the Phys+ and Chem+ categories in comparison to the Bio+ and Other categories were relatively large. This indicates that university/career needs and good

[16] Wilks' lambda = 0.866, $F(21,6946.61) = 17.01$, $p. < 0.001$, $\eta_{p2} = 0.05$ (20 multivariate outliers deleted from analysis)
[17] All items significant at $p<0.001$: $F(3,2425)$:[a] =12.30, $\eta_{p2} = 0.02$, [b] =59.58, $\eta_{p2} = 0.07$, [c] =9.62, $\eta_{p2} = 0.01$, [d]=9.30, $\eta_{p2} = 0.01$, [e] =56.71, $\eta_{p2} = 0.07$, [f] =16.98, $\eta_{p2} = 0.02$, [g] =8.54, $\eta_{p2} = 0.01$

results were considerably more important to students within Phys+ and Chem+ in relation to the other two subject choice categories.

S11: What reasons do students give for not choosing senior science?

Students choosing no science subjects for Year 11 were asked to respond to seven items suggesting reasons for their decisions. Figure 6.4 shows mean responses and error bars indicating two standard errors above and below the mean. The dotted line indicates the "Unsure" point, with means to the right of this indicating increasing agreement.

The most strongly endorsed items were that students could not picture themselves as scientists, and that they did not need science for university or a career. The items rated as least important were timetable issues and a lack of good teachers. The more detailed picture underlying these results is shown in the frequency data depicted in Figure 6.5.

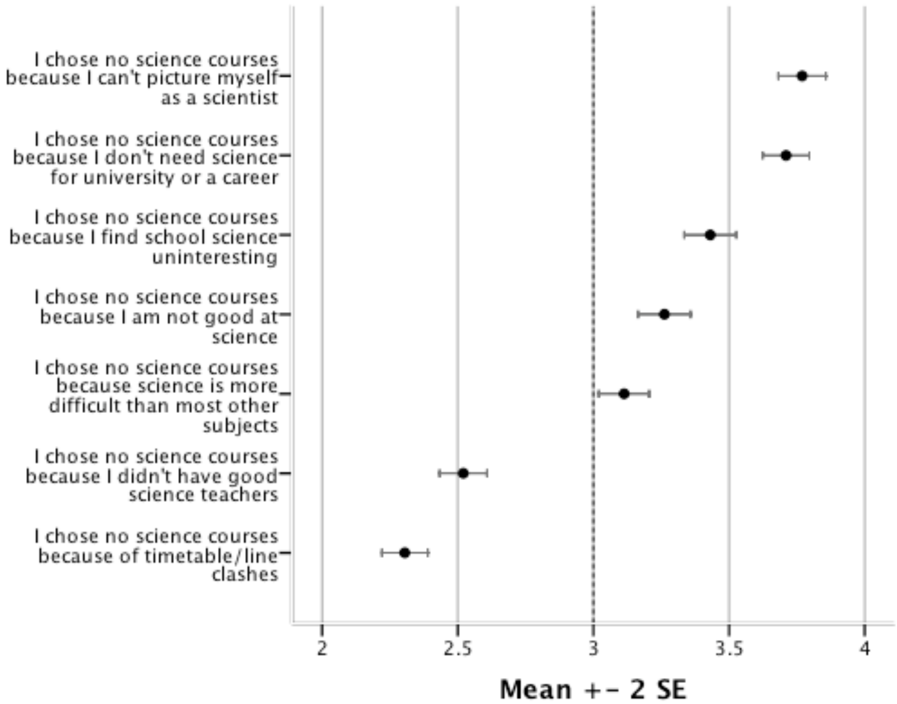


Figure 6.4: Means of students' responses to questions about why they chose to study no science in the following year. [Response scale: 1 = Strongly disagree, 2 = Disagree, 3 = Unsure, 4 = Agree, 5 = Strongly agree]

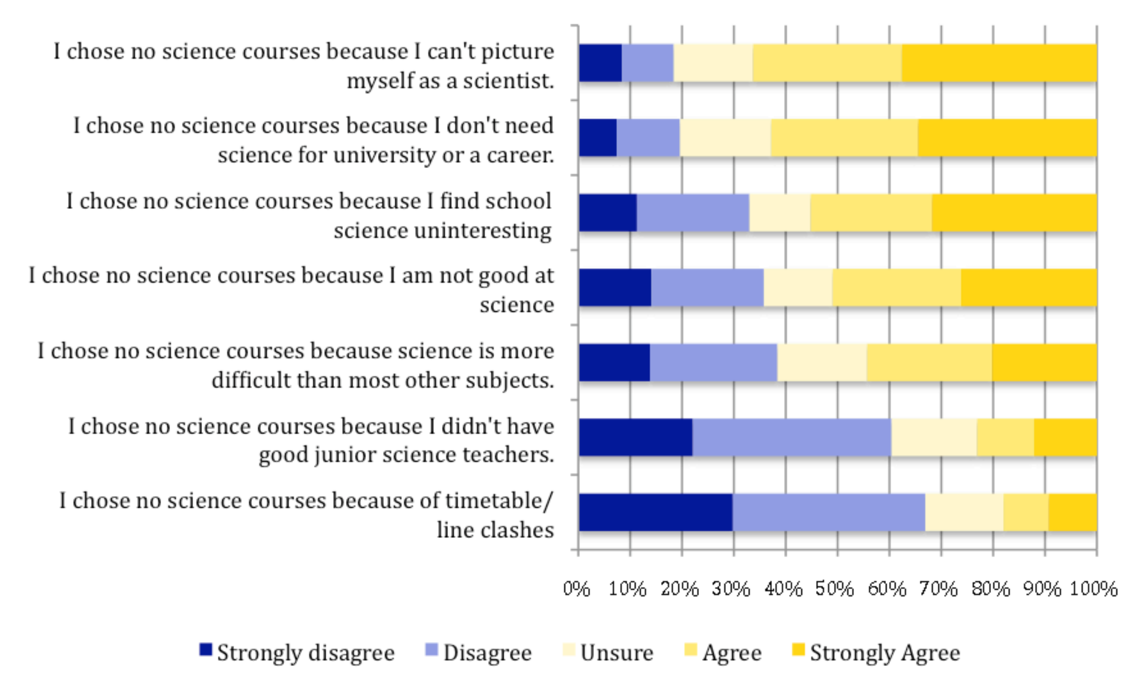


Figure 6.5: Percentage breakdown of students' responses to items explaining why they chose not to study science in Year 11.

Figure 6.5 shows that two out of three students agreed that they chose no science because they could not picture themselves as a scientist, while 62% agreed it was because they did not need science for university or a career. Lack of interest and perceived ability were the next most common reasons, with 55% and 50% of students agreeing with these items respectively.

In summary, the two groups of students - those choosing science, and those not choosing science - provided broadly consistent findings about the reasons for their choices in that the direct influence of teachers was less important to both groups than their perceptions of science in relation to university or career plans.

S12: Are students' enrolment decisions associated with their attitudes to and perceptions of science?

To explore the relationship between students' science subject decisions for Yr 11 and their attitudes to school science, the mean responses to the four items relating to students' perceptions of school science and their self-rated ability were compared by MANOVA across the five subject choice categories. There was a significant multivariate effect[18], as well as meaningful significant main effects for each of the four items[19]. The relationship between subject choice category and mean rating for each of the four items is shown in Figure 6.6. The middle point of the scale is 3, so that mean responses above three indicate agreement, while mean responses below three indicate disagreement with particular items.

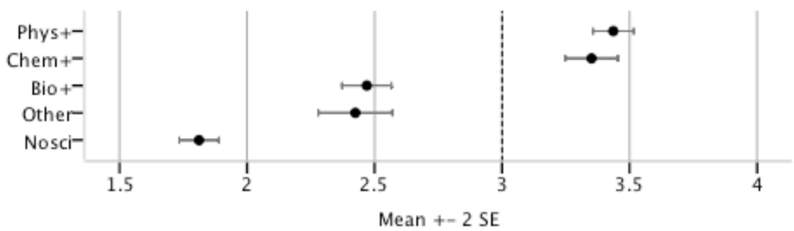
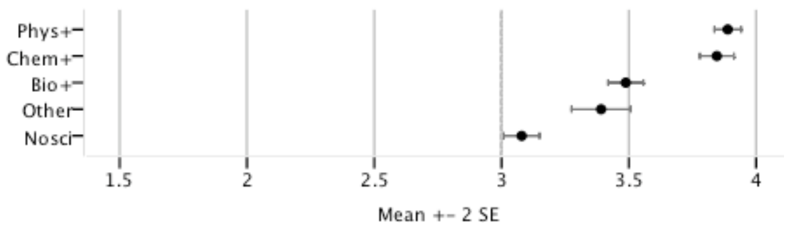
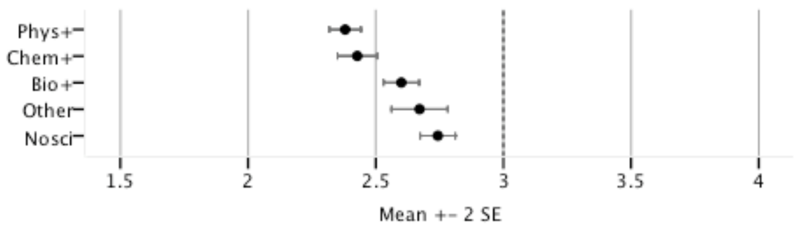
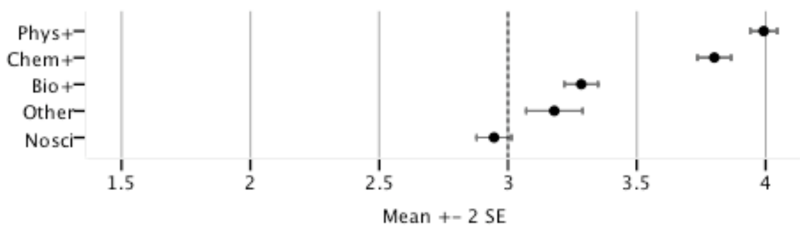
Item	Means and standard errors of item for five subject choice categories
I like school science better than most other school subjects [a]	
What I learn in school science helps me to make sense of the world[b]	
What I learn in school science makes me feel pessimistic (negative) about the future [c]	
How would you rate your own academic ability in science this year compared to others in your class? [d]	

Figure 6.6: Means of students’ responses to four items about their attitudes to school science, for each of five science subject choice categories.

[18] Wilks’ lambda = 0.674, F (16,8478) =72.91, p. <0.001, $\eta_{p2} = 0.09$ (23 multivariate outliers deleted from analysis)

[19] All items significant at p<0.001; F(4,2778): [a]= 257.04, $\eta_{p2}= 0.27$; [b]= 103.57, $\eta_{p2} = 0.13$; [c] = 17.39, $\eta_{p2} = 0.02$; [d] = 180.42, $\eta_{p2} = 0.21$

As is apparent in Figure 6.6, post hoc tests showed a similar pattern for the items 'I like school science better than most other school subjects' and 'What I learn in school science helps me to make sense of the world'. For these items, the means for the Phys+ and Chem+ categories were significantly higher than for the other three categories, falling well into the agreement side of the scale. By contrast, the means for Bio+ and Other+ were both significantly less than for the Phys+ and Chem+ categories, falling towards the disagreement side of the scale. Means for all these categories were significantly higher than for the Nosci category.

While there was greater overlap between subject choice categories for the item 'What I learn in school science makes me feel pessimistic (negative) about the future', the mean for the Phys+ category was significantly lower than Bio+, Othersci and Nosci. For the item 'How would you rate your own academic ability in science this year compared to others in your class?' the mean for the Phys+ category was significantly higher than all the other categories, the mean for the Chem+ category was significantly higher than Bio+, Other and Nosci, and all categories were significantly higher than the Nosci category. These results are supported by the findings from the chi-squared tests[20]. The pattern of means for self-rated ability across the different subject choice categories was parallel for girls and boys.

In summary, these results indicate that, in general, inclusion in the Phys+ and Chem+ categories is associated with more positive perceptions and greater perceived science ability, while Othersci and Nosci categories were associated with more negative perceptions and lower perceived science ability. Bio+ students were in the middle of the range of means. These results may be in part an artefact of the number of science options defined within the categories (for example, only the phys+ category could contain students choosing all four science options, therefore, the students who liked science), but nonetheless reflect consistent meaningful differences within the categories as defined.

[20] All items significant at $p<0.001$; $\chi2$ (16): [a] = 876.65; Cramer's V = 0.30: [b] = 452.73; Cramer's V = 0.18: [c] = 133.57; Cramer's V = 0.10: [d] = 775.82; Cramer's V = 0.24

S13: Is there an association between students' reasons for choosing or not choosing science and their sex, school type or school sector?

For each of the two groups of students: those choosing at least one science and those choosing no science, a MANOVA was conducted to test for associations between sex, school type and sector, and reasons for choosing or not choosing science.

Within the group of students who chose at least one science, MANOVA detected no meaningful significant multivariate association between reasons for choosing science and sex, school type or sector. Within the group of students who chose no science, there were meaningful significant associations between sex and three of the seven items relating to their reasons for not choosing science, as shown in Figure 6.7[21].

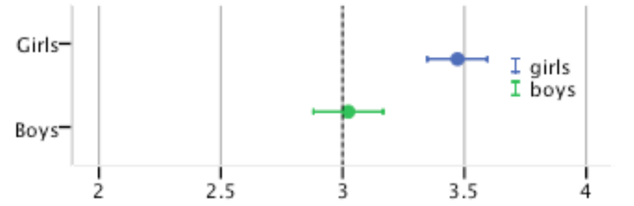
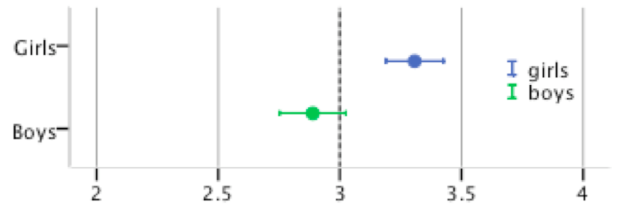
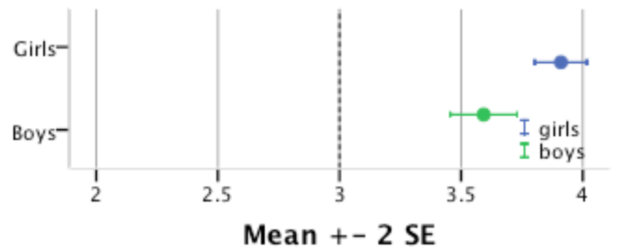
Item	Means and standard errors of item for boys and girls
I chose no science subjects because I am not good at science [a]	
I chose no science subjects because science is more difficult than other subjects [b]	
I chose no science subjects because I can't picture myself as a scientist [c]	

Figure 6.7: Means and standard errors of responses of boys and girls to three items related to them choosing no science for the following year. [Response scale: 1 = Strongly disagree, 2 = Disagree, 3 = Unsure, 4 = Agree, 5 = Strongly agree]

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[21] Wilks' lambda = 0.940, F (7,837) = 7.67, p. <0.001, η_{p2} = 0.06 (4 multivariate outliers deleted from analysis)

Figure 6.7 shows that girls agreed slightly but significantly more than boys with the statements "I chose no science subjects because I am not good at science", "I chose no science subjects because science is more difficult than other subjects" and "I chose no science because I can't picture myself as a scientist" [22]. These findings were supported by the results of chi-squared tests [23].

In summary, this finding highlights a common feature of the reasons for not choosing science. All the differences between girls and boys related to students' personal perceptions of their ability and science, rather than external issues related to careers, teachers or timetables. For girls, these three reasons for not choosing science: that I am not good at science, that science is more difficult than other subjects, and that I can't picture myself as a scientist, relate coherently to their perceptions of being less able in science than their peers, as reported in Chapter 4.

S14: Which stage of schooling do students believe had the most influence on their decisions about taking senior science?

As shown in Figure 6.8, 80% of students considered their middle secondary years (Years 9 & 10) to have had the greatest influence on their decisions. Overall, about 92% of students believed that their secondary school experiences were more influential than their primary school experiences. Crosstabulations found that students' responses to this item were not significantly associated with their sex, state/territory, school sector, type or location. By contrast, crosstabulation of dichotomous science choice (i.e. science or no science) and stage of school revealed a small significant association[24]. The frequencies with which students choosing at least one science or no science responded to this item are shown in Figure 6.9.

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[22] All items significant at $p<0.001$: $F(1,853)$: [a] = 21.23 $\eta_{p2} = 0.02$; [b] = 19.28; $\eta_{p2} = 0.02$; [c] = 12.93 $\eta_{p2} = 0.02$

[23] All items significant at $p<0.001$: $\chi2$ (4): [a]= 36.12; Cramer's V = 0.20; [b] = 27.85; Cramer's V = 0.18; [c] = 20.00; Cramer's V = 0.15

[24] $\chi2$ (3) = 79.96; $p<0.001$; Cramer's V = 0.15

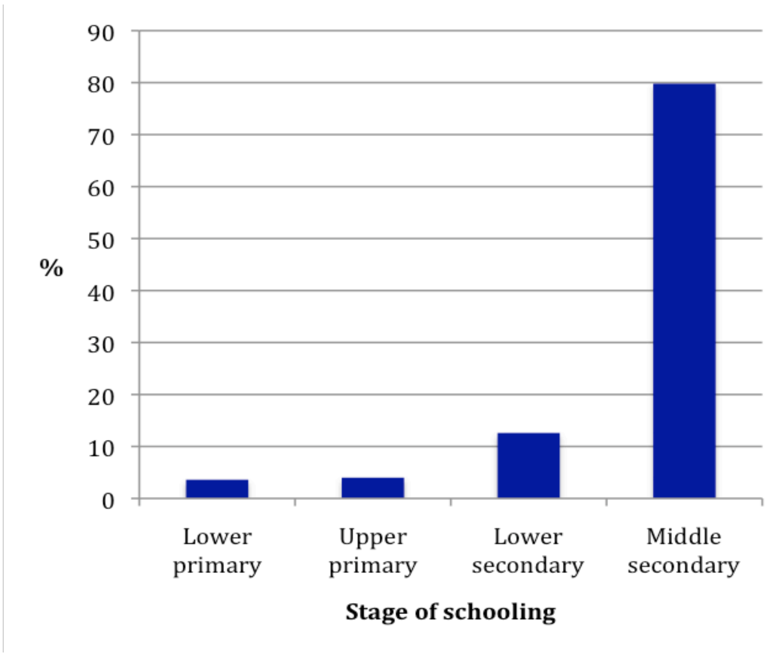

Figure 6.8: Frequencies of student responses to the item "Which stage of your schooling do you think had the greatest influence on your decision about whether or not to take senior science".

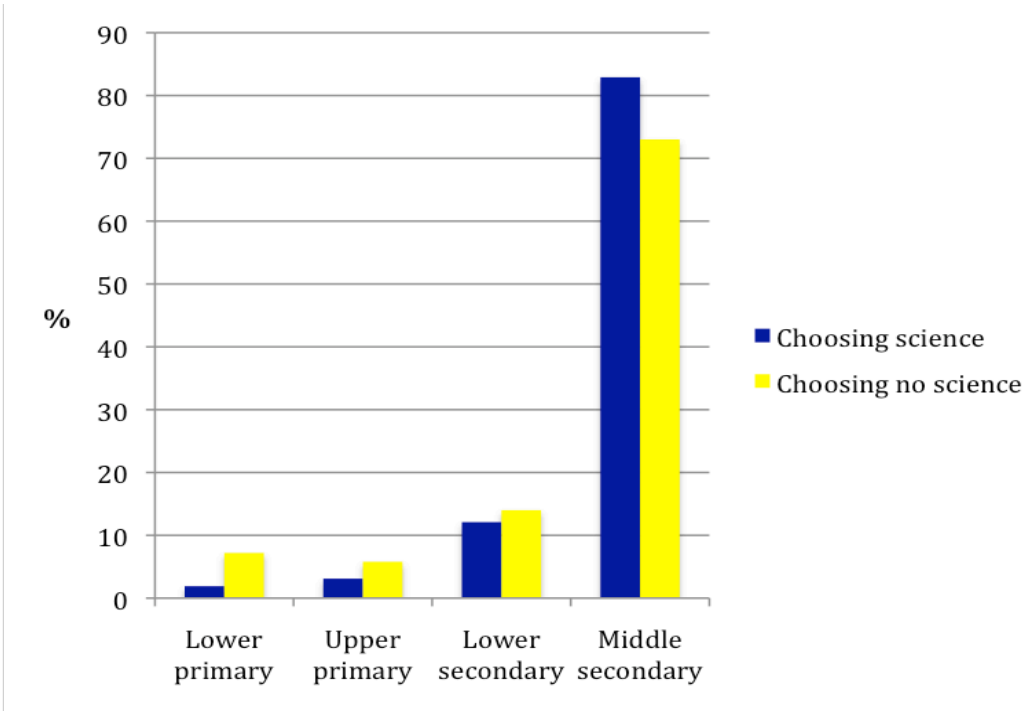

Figure 6.9: Students' views about which stage of their schooling was most influential on their decisions to take or not take senior science.

As suggested by Figure 6.9, students choosing no science were more likely to believe that they were influenced by their primary school experiences than were students choosing at least one science. The latter were more likely to believe that they were influenced by their middle secondary stage.

S15: Which people do students consider the most influential in helping them make their decisions about choosing science?

Students were asked about the influence of others on their decisions about taking science in Year 11. They were invited to rate their agreement with the item "How influential were the following people in helping you decide about choosing [X] (physics/chemistry/biology/this science subject/no science)? The people nominated were: mother; father; close friend; older student; older siblings; school careers advisor and a science teacher they'd had in the last two years. The responses of students choosing no science and those choosing at least one science were compared.

This information is shown in Figure 6.10. The middle point of the 4 point Likert scale is 2.5. Mean responses above this value indicates that the person was influential to some degree, while responses to the left of this value indicate that the students did not view the person in question as influential. The top panel shows the responses of students choosing at least one science in Year 11, while the bottom panel shows the responses of students choosing no science in Year 11.

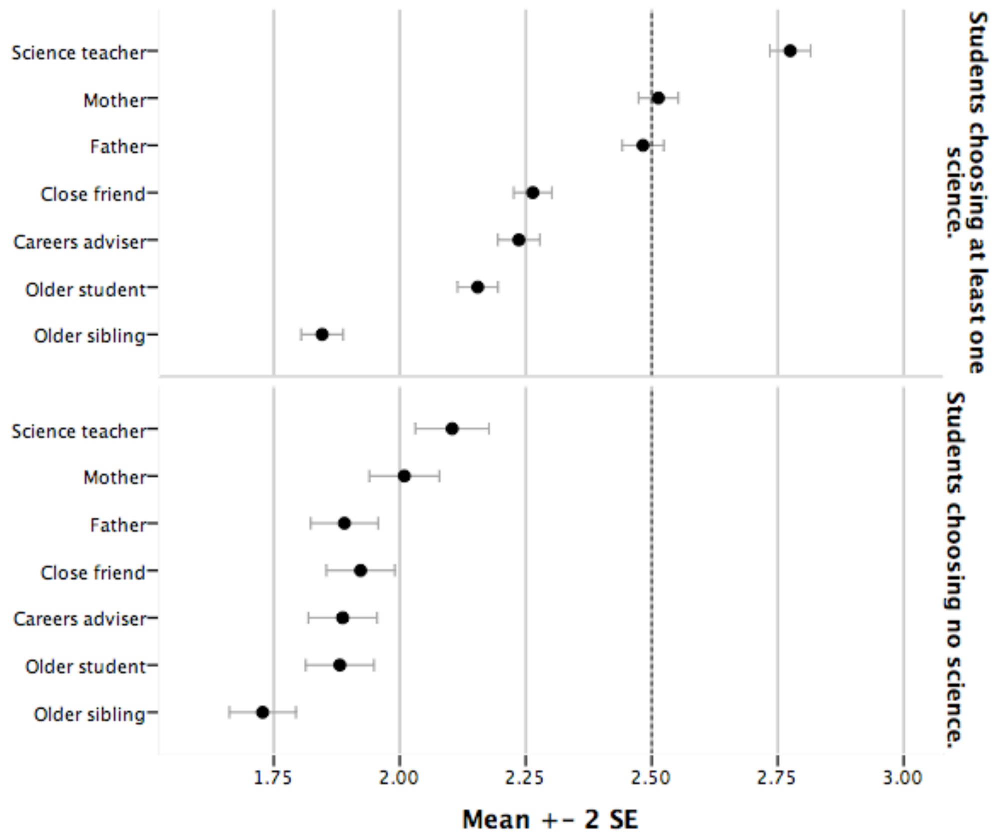

Figure 6.10: Mean agreement by "Science" and "No science" groups on the influence of people in helping them to decide about their science choices [ratings on a scale from 1 (Not at all influential) to 4 (Very influential)].

As shown in Figure 6.10, students believe that the most influential people were their science teachers, followed by their mothers and fathers. Least influential were the students' older siblings, followed by older students and finally careers advisers. It must be emphasised that this finding may be related to differences in availability of potential sources that exists within the sample, and indeed the population, and should be interpreted accordingly. Older siblings in particular, and fathers and mothers to a lesser extent may have been either absent, or unavailable or seldom available to help students with their subject choice decisions.

The pattern observed in the data was particularly strong among the students who chose at least one science, but less so among the students choosing no science. The more detailed picture underlying these findings is shown in Figure 6.11.

This figure shows that close to 70% of students choosing at least one science thought that a science teacher was somewhat or very influential on their decision to take science. Just over 50% of students who chose at least one science reported that their parents were influential to some extent. Though the three major influences were the same for the students choosing no science, the percentage of respondents acknowledging the influence of their teacher, mother or father was much less.

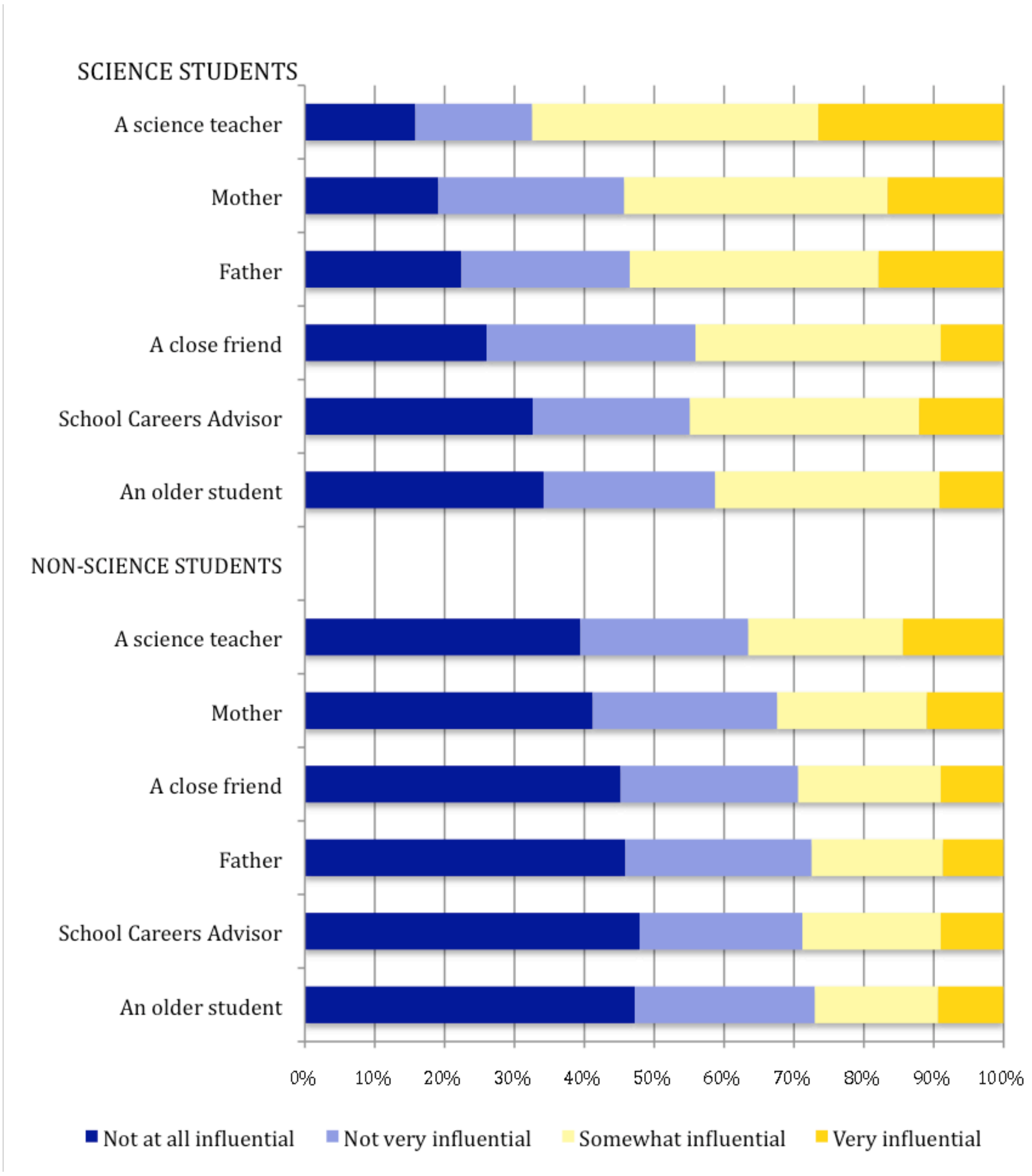

Figure 6.11: Percentage breakdown of students' ratings of the influence of others in helping them decide about choosing or not choosing science [ratings on a scale from 1 (Not at all influential) to 4 (Very influential)].

In fact, as shown in Figure 6.10 and Figure 6.11, the group of students choosing no science appeared to be less influenced by all nominated persons (other than older siblings) than were students choosing science.

The differences apparent in Figure 6.10 between mean responses of students choosing science and those choosing no science were explored by a MANOVA across the Science/No science categories for all items. There were significant and meaningful differences between means of the Science and No science cohorts for all possible influences except for the "Older sister or brother" influence.[25] As suggested by Figure 6.10, the students choosing science agreed significantly more than the non-science cohort that they were influenced by anyone (other than older siblings). These findings are supported by Chi-square tests[26]. This association between influence-ability (based on self-reported data) and choosing science warrants further exploration, as it seems possible that both may be related to additional variable/s not addressed in this study.

Differences between mean responses to these items across sex, school type and sector, location, and state/territory were explored by a series of three MANOVAs. There were no significant differences between mean responses across any of these variables except sex, which is described in more detail below.

Sex differences

The MANOVA of the mean responses of the whole cohort of boys and girls for the seven items relating to influential figures showed a significant different for only one item; the influence of students' fathers[27]. This result is shown in Figure 6.12. The middle point of the scale is 2.5, so that mean responses to the right of this value indicate that the father was influential to some degree, while responses to the left of this value indicate that the students did not view the father as influential.

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[25] Wilks' lambda = 0.891, F (7,3348.00) =58.62, p. <0.001, η_{p2}= 0.11 (7 multivariate outliers deleted from analysis), univariate effects p<0.001, η_{p2} > 0.02 – 0.08.
[26] All items significant at p<0.001; $\chi 2$ (12): [Mother] = 209.51; Cramer's V = 0.14. [Father]= 308.57; Cramer's V = 0.17; [Close friend] = 133.89; Cramer's V = 0.11; [Older students] = 89.61; Cramer's V = 0.09. [Careers adviser] = 90.99; Cramer's V = 0.09. [Past science teachers]= 3313.00; Cramer's V = 0.18.

[27] Wilks' lambda = 0.984, F (7,3338.00) =7.56, p. <0.001, η_{p2} = 0.02 (7 multivariate outliers deleted from analysis), univariate effect p<0.001, η_{p2} = 0.01

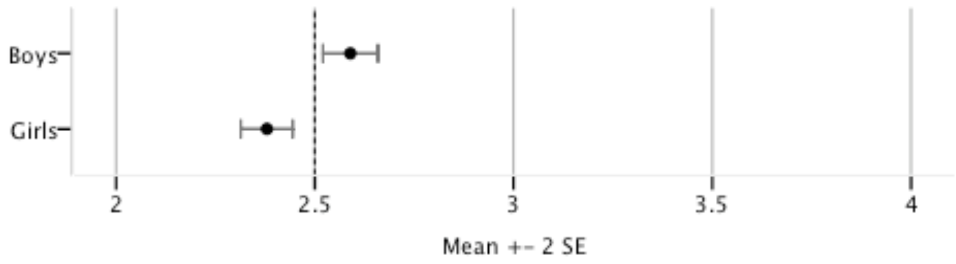

Figure 6.12: Mean responses of boys and girls to the item "How influential were the following people in helping you decide about choosing [X]?" for the "Father" option.

As shown in Figure 6.12, boys were significantly more influenced by their fathers than were girls[28], though this was a small effect. This finding is supported by results of the chi-squared test[29] and depicted in more detail in Figure 6.13. The figure shows that boys agreed more frequently than girls that their fathers were somewhat or very influential, and less frequently that their fathers were not very or not at all influential.

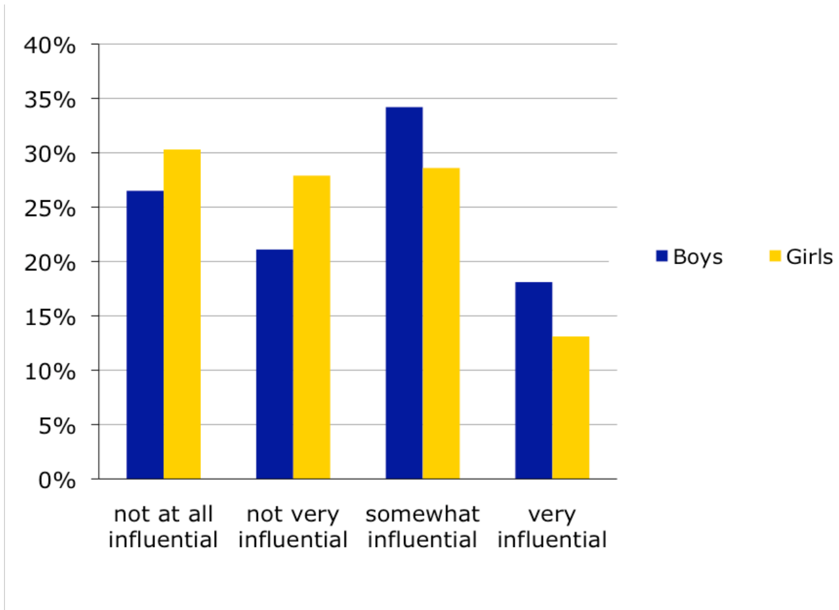

Figure 6.13: Frequency of responses to the influence of the students' fathers on their science choices for the following year.

In summary, according to students, the people who had the greatest influence on their decisions about science were their science teachers, mothers and fathers. Least

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[28] $F = 36.47$ p. <0.001, $\eta_{p2} = 0.01$

[29] $\chi 2$ (3) = 43.10; $p<0.001$; Cramer's V = 0.11

influential were the students' older siblings. Students choosing no science reported, on average, being less influenced by anyone (other than older siblings) than the students choosing at least one science, and this represented a significant and meaningful difference between the two cohorts. Boys were more influenced by their fathers in their science choices than were girls.

The results of this investigation contrast with the expectations of science teachers. Chapter 3 reported that science teachers considered their own advice to being less influential than advice from friends, older siblings, and parents. However, students' opinions suggest that science teachers substantially undervalue the impact of their own advice on students' decisions.

Conclusion

Of the 3759 respondents, 2851 had chosen to enrol in one or more Year 11 science subjects, while 908 had chosen no science subjects. Significant but not unexpected differences were found between the choice categories. Respondents in the Phys+ and Chem+ categories tended to have more positive attitudes to school science and to rate their academic ability in science higher than students making other choices. Students choosing no science were more inclined than others to agree that school science made them feel pessimistic about the future, and to disagree that science helped them make sense of the world. They also tended to rate their academic ability in science much lower than other students. For each investigation, mean responses from students in the Bio+ and other science categories were between those choosing physics or chemistry and those choosing no science.

Overall, students were motivated to choose science primarily by their anticipation that senior science subjects will be interesting, followed by the need to take science for university or a career. Good teachers and/or teacher encouragement were the least prevalent reasons for taking science. This pattern was more or less consistent across all science choice categories. Students responding in the context of physics or chemistry were more inclined to agree with all of these items compared to those replying in the context of other science, with students responding in the context of biology in the middle. The two exceptions to this pattern were that students choosing biology were as likely as those choosing physics or chemistry to do so because of anticipated interest in the subject, and students responding in the context of chemistry agreed more than other students that they chose their subject because they had good science teachers. Strategic reasons and good results were relatively more important to students within Phys+ and Chem+ than those in the other two categories.

Most students choosing no science did so primarily because they did not aspire to work in science related fields. Two out of three could not picture themselves as scientists, and felt that science would not figure prominently in their university or career options. Around 55% felt that school science had been uninteresting, while half decided against Year 11 science because they felt they were not good at science. The items rated as least important were timetable issues and a lack of good junior science teachers. Girls were significantly more inclined than boys to attribute their decision to their ability in science and subject difficulty, and an inability to picture themselves as scientists.

Regardless of their ultimate choice, students' felt their decisions about taking science were influenced predominantly by their experiences in Years 9 and 10. Overall, about 92% of students believed that their secondary school experiences were more influential on their decisions than their primary school experiences.

Students choosing no science were influenced more often than expected by their earlier experiences, and less often than expected by their experiences over the last two years. Conversely, students choosing at least one science were influenced more often than expected by their recent experiences, and less often than expected by their primary school experiences.

In terms of external influences on their decisions, overall students considered science teachers to have been the greatest influence in helping them decide whether to take science subjects in Year 11. Teachers were followed by mothers and fathers, and then close friends. Boys choosing science tended to attribute significantly more influence to their fathers than did girls choosing science, though among students choosing no science, fathers were considered to be only as influential as close friends, if not less so. Careers advisers, older students and siblings were considered to have had the least influence. Students choosing no science tended to rate the influence of all others on their decisions substantially lower than did those choosing science.

Chapter 7 : Students' opinions about science careers and tertiary study

Introduction

The student survey explored students' general opinions about science careers as well as their personal intentions with respect to science as a career or tertiary study option. The following questions were used as a framework for investigation:

S16: What are students' views about science-related university study and careers?

S17: Do Year 10 students' intentions about science-related university study vary with Year 11 science subject choices or perceived ability?

S18: Where do Year 10 students get their ideas about science careers?

S19: How well do relative perceptions about careers, ability and enjoyment of school science predict students' intentions to study science at university?

Student responses to these questions are depicted using graphs of means and standard errors of responses to each item, together with, in some cases, bar charts presenting frequencies of responses at each response value.

S16: What are students' views about science-related university study and careers?

The first source of information about students' views of science careers was their responses to the ten-item Career Interest in Science scale from the Test of Science Related Attitudes (TOSRA) instrument. A second set of views about post-secondary study and careers in science was identified through students' responses to four questions concerning more specific aspects of science careers.

TOSRA Career Interest in Science scale

Respondents were asked to rate their levels of agreement with five positively worded and five negatively worded statements about science careers using a five point Likert-type response format. Responses to individual items were analysed by coding and calculating the item means and standard errors. Responses to the scale as a whole were analysed by coding and reverse scoring the negatively worded items and calculating scale means. Differences in responses across sex, school type and school sector variables were identified by a series of ANOVAs, which also allowed investigation of interaction effects between these variables.

Responses to TOSRA items

The mean responses of students to the individual TOSRA Career items are shown in Figure 7.1. The middle point of the scale is 3, so that mean responses above three indicate a mean agreement, while mean responses below three indicate disagreement with particular items. The figure shows that students on average endorsed most strongly the statements that they would dislike being a scientist or working in a science laboratory after leaving school. This was despite their roughly equivalent level of agreement that these would be interesting careers, and their concomitant disagreement that these careers would be dull and/or boring. The least popular of these career-related items was the idea of being a science teacher.

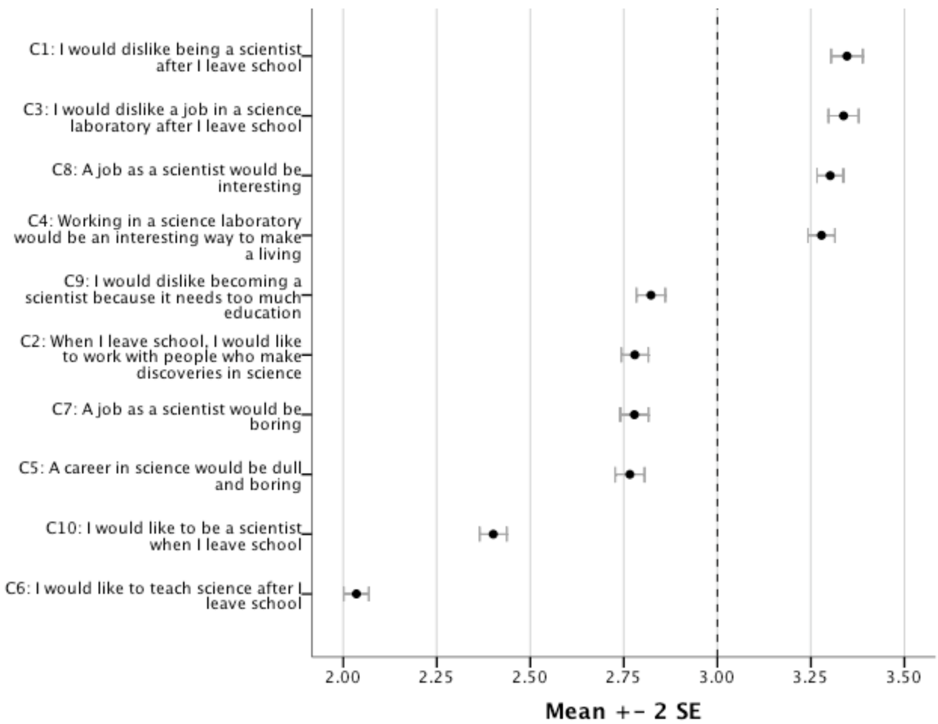

Figure 7.1: Means and standard errors of students' agreement with TOSRA statements concerning science careers. [Response scale = 1 (Strongly disagree); 2 (Disagree); 3 (Unsure); 4 (Agree) and 5 (Strongly agree)].

These results are depicted in more detail in Figure 7.2, which compares the percentage breakdown of respondents for each of the agreement points for the ten items. The figure shows that nearly half the sample agreed they would dislike being a scientist or working in a science lab after leaving school. However, just over 50% agreed that a science job would be interesting. The students' reported dislike of science as a career, then, seems not to be because they think a science career would be boring, or because it requires too much education. Only around 8% of respondents agreed they would like to be science teachers, and 72% disagreed.

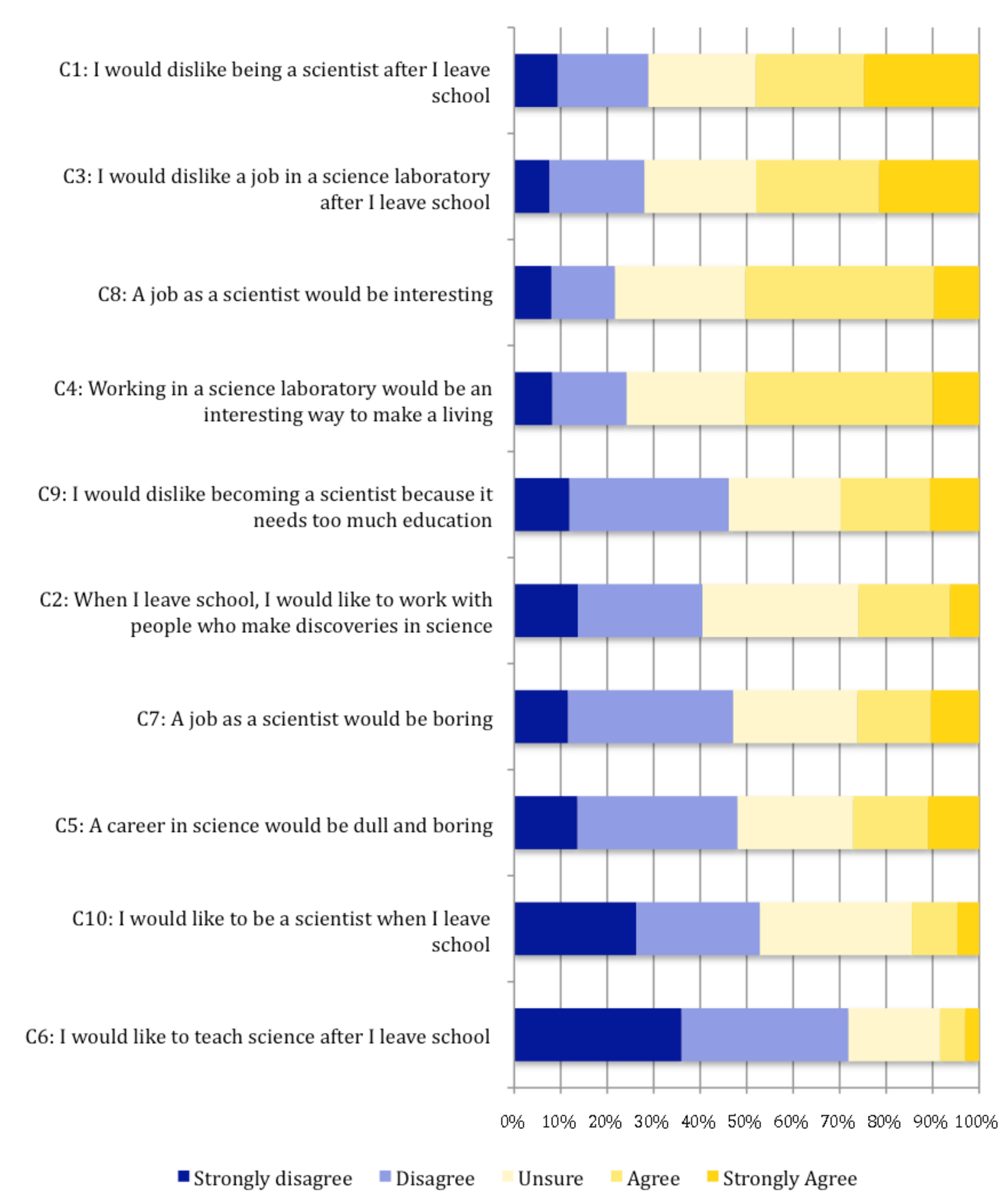

Figure 7.2: Percentage breakdown of student agreement with TOSRA statements on science as a career.

Comparisons of TOSRA Career scale means

The comparison of means for the entire TOSRA Career scale across the sample variables showed no meaningful significant difference across sex, school type or sectors; nor were there any interaction effects between these variables.

What students think about availability and pay of science careers, and their intentions to study science in post-secondary education

The other source of information about students' views of post-secondary study and careers in science was their responses to the following four statements:

- It is likely that I will choose a science-related university course when I leave school;
- I think science careers are well paid;
- It is fairly easy for a person with a university science degree to get a job in science;
- School science has opened my eyes to new and exciting jobs.

Students' responses to these items are summarised in Figure 7.3. The figure shows means of the responses on 5 point Likert-type scales, with error bars indicating two standard errors above and below the mean value. The dotted line represents the "Unsure" point, with means to the right of this indicating increasing agreement.

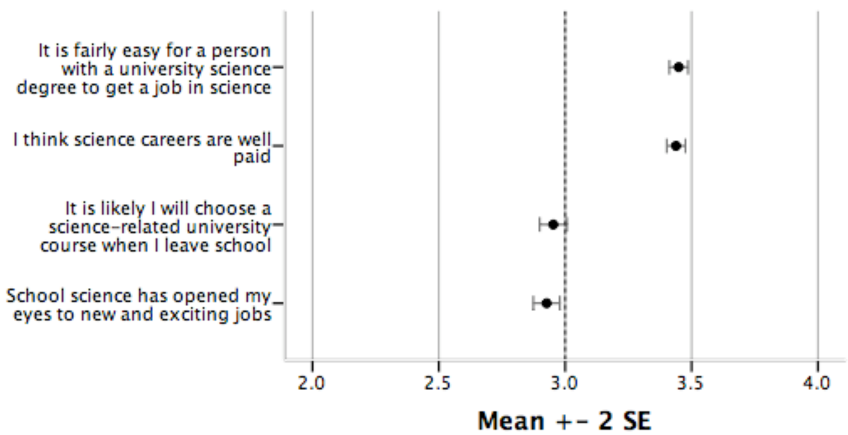

Figure 7.3: Means and standard errors of student responses to four questions about their views of science careers and further post secondary science study. [Response scale: 1 = Strongly disagree, 2 = Disagree, 3 = Unsure, 4 = Agree, 5 = Strongly agree]

It is apparent from Figure 7.3 that students were inclined to agree both that science careers are well paid and it is easy to get a job in science. However, they were less inclined to agree that they would choose a university science course, or that they had been made aware of new and exciting jobs from school science. The more detailed picture underlying this result is shown in Figure 7.4.

As the figure shows, approximately 50% of students agreed that science jobs were easy to get, and only about 15% disagreed. Around 52% agreed that science careers are generally well paid, while 13% disagreed and 35% were unsure. Figure 7.4 also shows that about 39% of the students agreed that it was likely they would choose a science-related university course after leaving school. This item attracted the fewest 'unsure' responses in this set (20%), indicating that most students were already reasonably certain about whether they would undertake a science related university course. Only 35% of students agreed that school science had opened their eyes to new and exciting jobs.

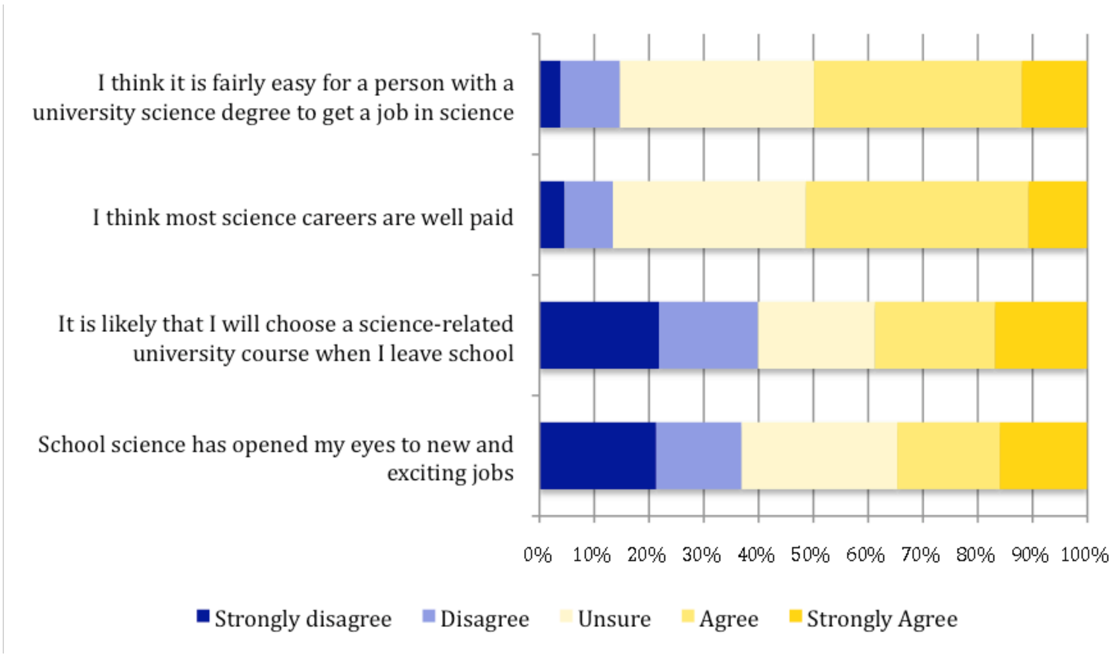

Figure 7.4: Percentage breakdown of student agreement with statements on science as a career.

Three MANOVAs were conducted to test the association between students' responses to the four career items and sample variables of sex, school type and sector, location and state/territory. No meaningful significant multivariate differences were found.

In summary, students agreed to a similar extent that they thought science would be an interesting career, yet personally they would not like a job in science. This is an interesting juxtaposition of views that begs the question of why many of the students anticipated disliking a job in science despite thinking that it would be interesting. Their responses to the subsequent items suggested that this was not because of concerns about poor pay or difficulty obtaining a job.

S17: Do Year 10 students' intentions about science-related university study vary with Year 11 science subject choices or perceived ability?

The question "It is likely that I will choose a science-related university course when I leave school" was explored in more detail, as university study forms a crucial bridge between science at school and science as career. The means of student responses to this item for the different subject choice categories are shown in Figure 7.5.

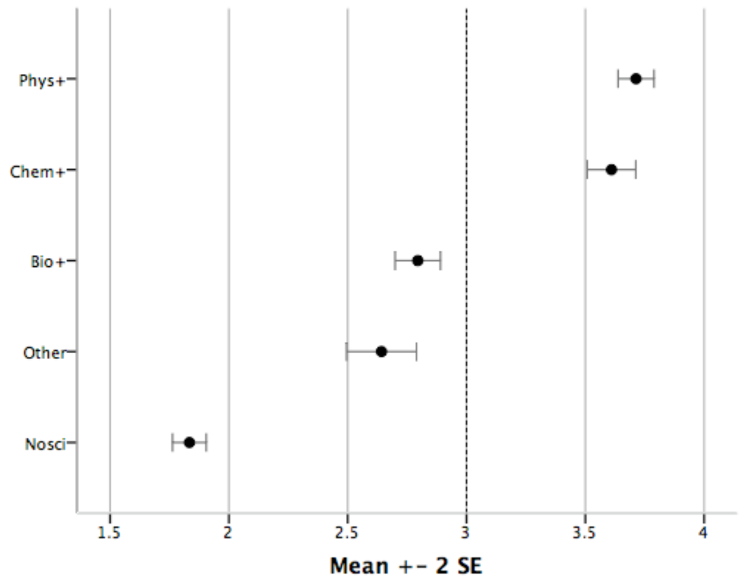

Figure 7.5: Means and standard errors of students' responses to the item "It is likely that I will choose a science-related university course when I leave school", broken down by subject choice category.

Figure 7.5 shows an association between subject choice category and university aspirations. Students' responses to this item were tested using one-way ANCOVA across the five subject choices to determine whether subject choice at school is associated with intentions regarding university science. ANCOVA was used to control for the likely effect of students' perceived ability in science on their university science intentions. The ANCOVA showed significant differences between students' reported intentions to study science after leaving school across the different subject choice categories[30], after controlling for perceived ability. There was also a small association between self-rated ability and intention to study science at university[31].

Bonferroni-adjusted planned contrasts indicated that the estimated marginal means (adjusted for the effect of the covariate) were all significantly different from each other ($p<0.001$). These results may reflect to some extent the definition of the categories, with the Phys+ category including science-inclined students choosing two or three different sciences. Nonetheless, even after controlling for perceived ability, Year 10 students choosing physics and/or chemistry were more likely than those in the other science categories to agree that they would choose a university science course.

In order to depict this relationship in more detail, the frequency of responses in each subject choice category is shown in Figure 7.6 below.

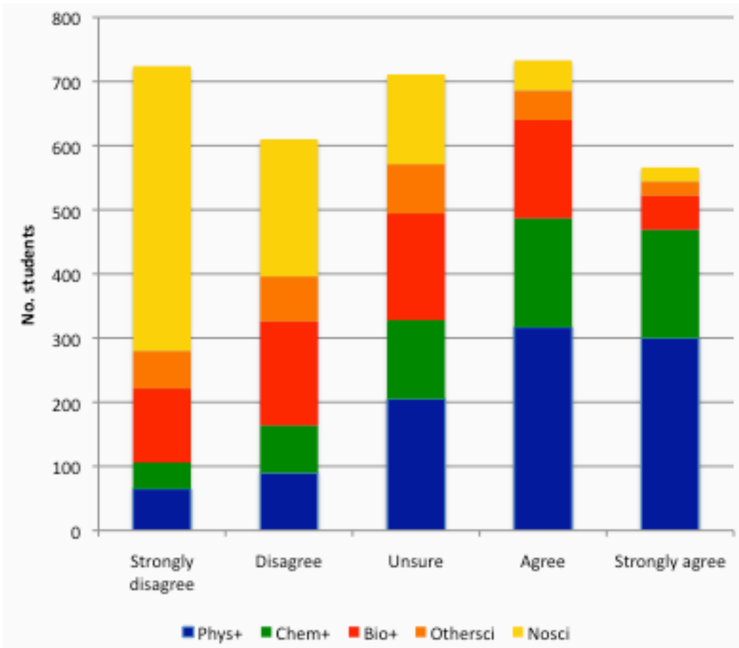

Figure 7.6: Frequency of student responses to the question "It is likely that I will choose a science-related university course when I leave school".

[30] $F(4,3338.00) = 229.43$, $p. <0.001$, $\eta p2 = 0.22$
[31] $F(1,3338.00) = 104.20$, $p. <0.001$, $\eta p2 = 0.03$

The results shown in Figure 7.6 show the contribution of responses in each of the subject choice categories to the overall results. The greater number of "Agree" and "Strongly agree" responses in the Phys+ and Chem+ categories can be seen, as can the greater number of "Disagree" responses in the No science category. These differences contributed to an overall large significant difference between the frequency of responses to the five different response options across subject choice categories.[32]

In summary, after controlling for perceived ability there was still a trend from the Phys+ through to Nosci category students in relation to their university intentions. Those choosing physics and/or chemistry were more likely than students in the other science categories to agree in Year 10 that they would choose a university science course. Students with higher perceived ability were also more likely to agree that they would choose a university science course.

S18: Where do Year 10 students get their ideas about science careers?

The students were asked to respond to four questions about the source of their ideas about science careers.

- My Year 10 science teacher often discussed science careers with my class
- I got most of my ideas about science careers from my parents
- I got most of my ideas about science careers from the media and movies
- I got most of my ideas about science careers from the school careers adviser.

Figure 7.7 shows means responses of students to a 5 point Likert-type format for each item, with error bars indicating two standard errors above and below the mean value. The dotted line indicates the "Unsure" point, with means to the right of this indicating increasing agreement.

[32] $\chi 2$ (16) = 1117.74; $p<0.001$; Cramer's V = 0.29

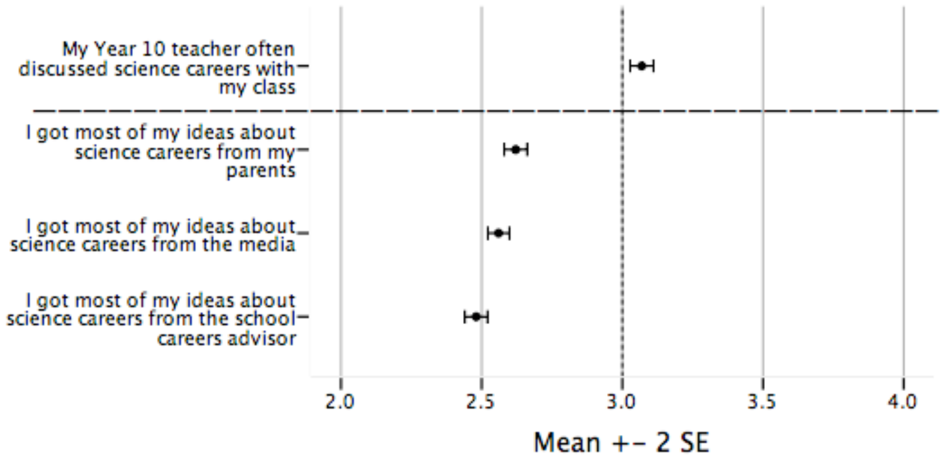

Figure 7.7: Means and standard errors of student responses to four questions about their ideas about science careers. Response scale: 1 = Strongly disagree, 2 = Disagree, 3 = Unsure, 4 = Agree, 5 = Strongly agree

As can be seen from Figure 7.7, in terms of the three items dealing specifically with "source of ideas", there was very little difference between the mean values for parents, media/movies and career advisers. For all three of these potential sources, the mean response of Year 10 students was between disagreeing and being unsure that these were the source of their ideas about science careers. The influence of these potential sources of information appears to be minor and relatively similar.

This result highlights the significant role of science teachers in informing students about science careers and the importance of having visiting scientists and other "real science" experiences in the classroom and beyond. The item that "My Year 10 teacher often discussed science careers with my class" was included here as it deals with sources of information about science careers, although has a different focus to the other three as it does not ask directly about teachers as the source of ideas. The mean response was slightly to the "agree" side of the unsure point, suggesting that students were getting some ideas about science careers from their science teacher. The more detailed picture underlying these results is shown in Figure 7.8.

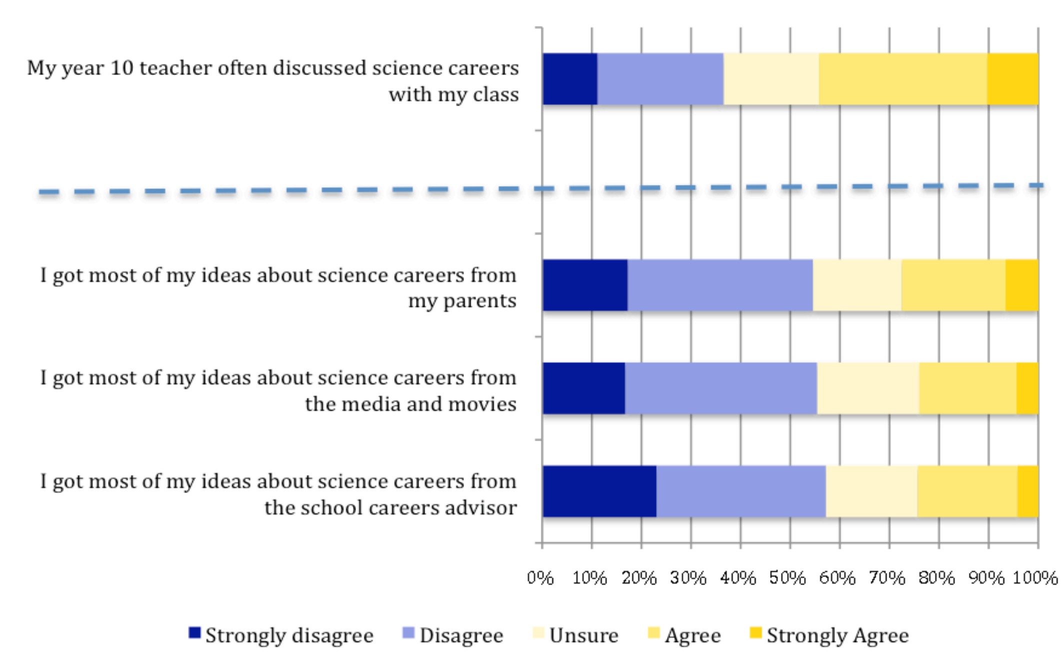

Figure 7.8: Frequencies of student responses to four questions about their ideas about science careers. Response scale: 1 = Strongly disagree, 2 = Disagree, 3 = Unsure, 4 = Agree, 5 = Strongly agree

As shown in Figure 7.8, less than a third of respondents to this question agreed that they got most of their ideas from parents, media/movies or school careers adviser, while over half the respondents disagreed that these were the source of most of their ideas. Just over 40% of respondents agreed that their Year 10 teacher often discussed science careers with their class.

Responses to these four questions were analysed using MANOVAs to identify any associations with sex, school type and sector, location and state. The only meaningful significant associations between any of these categories and student response were for the state category[33], which showed small significant differences in means for two of the items[34]. These results are shown in Figure 7.9.

[33] Wilks' lambda = 0.948, F (28,12126.89) =6.422, p. <0.001, ηp2 = 0.01
[34] F(7,3366) :[a] =4.998, p<0.001, ηp2 = 0.01, [b] =13.70, p<0.001, ηp2 = 0.03

My Year 10 science teacher often discussed science careers with my class [a]

I got most of my ideas about science careers from the school careers adviser [b]

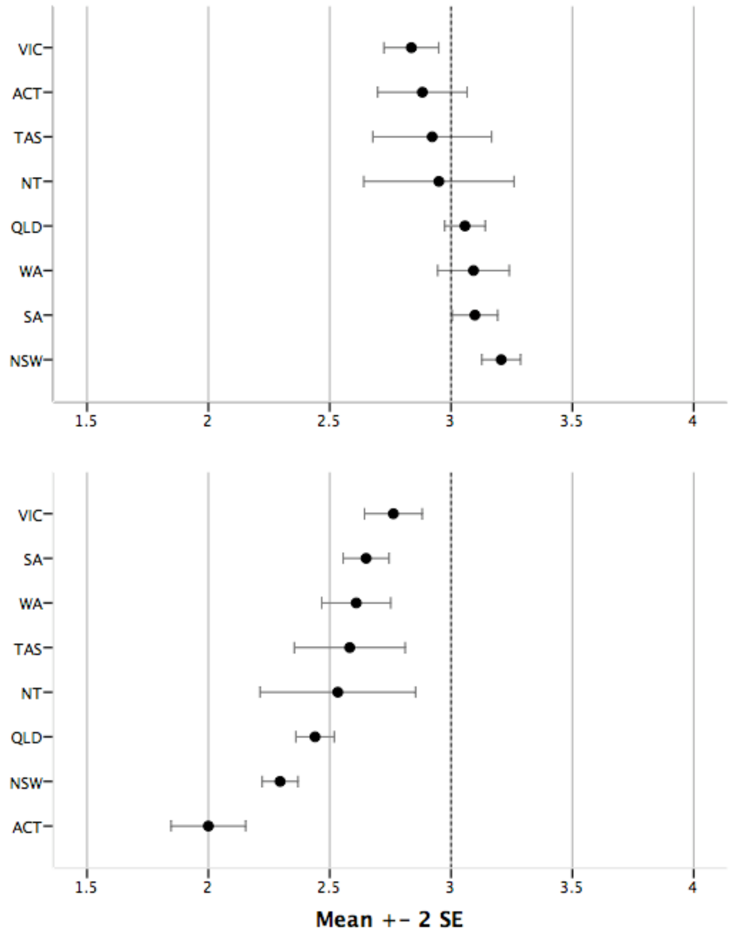

Figure 7.9: Means and standard errors for student responses to the items "My Year 10 science teacher often discussed science careers with my class" and "I got most of my ideas about science careers from the school careers adviser".

In summary, there was little agreement that students' parents, the media/movies and school career advisers were the source of most of the students' ideas about science, and less than half the students agreed that science teachers often discussed science careers with their class. Most of the students' ideas about science, then, appear not to come from one particular source, but seem likely to come from a combination of the sources mentioned above, or some other factors not investigated in this study. There were some differences between states/territories in relation to this question.

S19: How well do relative perceptions about careers, ability and enjoyment of school science predict students' intentions to study science at university?

A question of particular interest in this study was the relative contribution of student perceptions about science careers, their perceived science ability and enjoyment of science to their intentions to study science at university. Multiple regression was conducted to explore the association between five possible predictor variables to students' responses to the item "It is likely I will choose a science-related university course when I leave school" The items chosen were selected as indicators of enjoyment of school science, perceived ability, and different aspects of science as a career, (pay, ease of getting a job and excitement), some of which were highlighted in the teacher survey (see Chapter 3). The results of this procedure are shown in Table 7.1.

Table 7.1: Association between five possible predictor variables and students' responses to the item "It is likely I will choose a science-related university course when I leave school"

Model	Standardized Coefficients	t value	Sig.
	Beta		
I like school science better than most other school subjects	.30	14.750	.000
School science has opened my eyes to new and exciting jobs	.28	14.736	.000
How would you rate your own academic ability in science this year compared to others in your class	.11	5.780	.000
I think science careers are well paid	.09	5.550	.000
It is fairly easy for a person with a university science degree to get a job in science	.06	3.595	.000

The table shows that each of these five items makes a unique and significant contribution to explaining student responses to the item "It is likely I will choose a science-related university course when I leave school"[35], accounting for 36.5% of the variability in responses. The two items contributing most to the solution are the students' liking for school science (beta = 0.30) and awareness from school science of new and exciting jobs (beta = 0.28), followed by their perceived self-ability, which accounts for much less variability (beta = 0.11). The items relating to science career pay and ease of getting a job contributed very little to the solution, despite the relatively high mean agreement shown in Figure 7.3 that science jobs are both easy to get and well paid. These results highlight that Year 10 students' views about doing science later at university are related more to positive attitudes to science and science-

[35] $R^2 = 0.37$, adjusted $R^2 = 0.36$, $F(5,2653) = 305.52$, $p<0.001$ (18 outliers deleted from analysis)

related jobs from school, than pragmatic concerns related to remuneration and employment.

Conclusion

This chapter reported the results of investigations into Year 10 students' ideas about science careers and university courses. Respondents' attitudes to science careers were intriguing. While around 50% agreed that a being a scientist would be interesting, only 15% agreed that they would like to become scientists. This contrast is similar to that found by Jenkins and Nelson (2005) in the UK, who concluded that while many students believe science to be interesting and important, few personally aspire to science careers. The difference between students' objective views and their personal aspirations strongly implicates their sense of identity as a reference point for career and subject decisions (Schreiner & Sjøberg, 2007).

Respondents were generally positive about the availability of science careers and the salaries they attract. Half of all students agreed that it is fairly easy for a person with a science degree to gain employment as a scientist, and only about 13% disagreed that science careers were relatively well paid. This finding is at odds with the view of 45% of teachers that students' perceptions of science careers as poorly paid have been very or extremely influential in enrolment declines.

Respondents were evenly split over the likelihood of choosing a science-related university course once they left school, with around 40% agreeing, 40% disagreeing and the remainder unsure. As might be expected, there was a significantly greater tendency among students choosing physics and/or chemistry to agree that they were likely to enrol in a science related university course, compared to students choosing other options.

Only 35% of students agreed that school science has opened their eyes to new and exciting jobs. It is possible this relatively low percentage may again relate to the lack of information about science careers students have, or that students did not consider the jobs new or exciting. The first interpretation is consistent with previous research (e.g. Stables, 1996; Cleaves, 2005; Stagg, 2007) reporting low student familiarity with science careers.

In terms of where they obtained their knowledge about science careers, no single source stood out noticeably. Only 10% of students strongly agreed that their Year 10 teacher often discussed science careers with them, and 36% disagreed that this was the case. Fewer than 30% of students agreed that they obtained most of their ideas about science careers from their parents, the media or their careers advisors. There are several interpretations of this result. It may be possible that they obtained this information from sources other than those nominated, but it is also possible that they do not have much information at all. A further possibility is that students gleaned their information from a diverse range of sources, with no one source predominant. Regardless, the findings support teachers' emphasis on the need to develop closer links between students and scientists.

The two items predicting most strongly students' intentions to study science at university related to liking school science more than other school subjects, and being made aware through school science of new and exciting jobs. Pragmatic issues of remuneration of science careers and ease of getting a job, though generally viewed positively by respondents, were very small predictors of the university plans of these Year 10 students. Whether and how these views change in senior secondary school would be an interesting avenue to explore further.

In summary, around half the students considered science careers to be interesting, well paid and reasonable easy to find. Perhaps more significantly, fewer than 15% disagreed with the latter two points. This result undermines assumptions expressed by many science teachers in Phase One, and which are often heard anecdotally, that declines in student enrolments are due to negative perceptions about career prospects.

Chapter 8 : Understanding the declines in senior high school science enrolments

Introduction

In researching students' deliberations about taking senior science courses, the *Choosing Science* study drew on three sources of evidence: the opinions of science teachers, those of their Year 10 students, and conclusions from other research in this field. This chapter draws together these perspectives in an attempt to understand the reasons for the declines in science enrolments, and to establish a basis for recommendations aimed at encouraging more students to choose science. The discussion below is structured in terms of the relative likelihood that various factors contributed substantially to the enrolment declines in science.

Factors which are unlikely to have contributed to declines in enrolments

The study eliminated several factors as being unlikely to have contributed substantially to declines in science enrolments.

Declines in the level of interest in science among today's young people

Around half the science teachers in this study felt that the enrolment declines have been strongly influenced by declines in the level of interest in science among today's students. However, the study found no support for this proposition. The TOSRA comparison revealed no meaningful differences between the attitudes of today's students and those of a comparable cohort from 1977 in respect of four measures: enjoyment of school science, social implications of science, normality of scientists, and interest in science careers. It should be noted however that since the comparison was between two discrete points in time, the findings do not indicate whether attitudes may have fluctuated during the intervening period. Nevertheless, this result suggests that enrolment declines are due to factors other than a decline in Year 10 students' attitudes towards science.

Students' perceptions that science careers attract relatively low pay

Around 44% of the science teachers felt that the declines in science enrolments had been strongly influenced by students' perceptions that science careers are not well paid. About a third of these believed this reason to have been extremely influential. However, results from the student survey suggest that perceptions of low pay are unlikely to be behind enrolment declines. Only 14% of students disagreed that science careers were well paid, while 35% were unsure. While it is possible that students' views change during Years 11 and 12 as they become more familiar with various career prospects, perceptions of salaries do not appear to be a substantial disincentive at the critical time of choosing Year 11 subjects.

Students' perceptions that it is difficult to find a job in science

Around half of the students agreed that it is fairly easy for a person with a university science degree to get a job in science. Only about 15% of students disagreed with this prospect. Regardless of whether or not this perception is accurate, it indicates that it is unlikely that students are foregoing Year 11 science subjects because of perceptions that science jobs are difficult to find.

Students' perceptions that science careers are uninteresting

The issue of interest in science careers was shown to be quite complex. On the one hand, around half the students considered careers in science to be interesting, and a similar percentage agreed that working in a science laboratory would be an interesting way to make a living. On the other hand, when asked about their personal aspirations only 14% agreed they would actually like to be a scientist. This contrast between objective opinion and personal aspirations has been reported elsewhere (Jenkins & Nelson, 2005). In terms of the influence of career perceptions, it would seem students are not foregoing science enrolments simply because they perceive science careers to be uninteresting. Results from the TOSRA comparison also suggest strongly that there has not been a corresponding decline in students' levels of interest in science careers over the last three decades.

Students' experiences of primary school science

Some commentators have attempted to draw a causal link between students' experiences of science in primary school and the declines in science participation in senior high school. However, findings from *Choosing Science* challenge this assumption. Around 92% of the students believed their secondary school experiences had had the greatest influence on this decision, with around 80% considering their most recent experiences (Years 9 & 10) to have been the most influential. Of course, these responses are based on students' perceptions and it is possible that they may be unaware of the impact of earlier experiences. Nevertheless, from the perspectives of Year 10 students deliberating about further participation in science, primary school science experiences would seem to have had relatively little impact.

The students also considered their more recent science experiences to have been more enjoyable than those in primary school. Around 78% of students indicated they had enjoyed secondary school science more than primary school science. About 55% agreed their most recent experiences (Years 9 & 10) were the most enjoyable of all. This finding is surprising given the substantial body of research concluding that students' attitudes towards science are generally more positive in upper primary than in secondary school (e.g. see the review in Tytler, 2007).

This difference may be due to the fact that *Choosing Science* surveyed the retrospective opinions of Year 10 students, whereas most studies reporting declines in the level of enjoyment over time were either cross-sectional or longitudinal in design. In addition, some of these studies may not have taken into consideration the decline in attitudes to school in general over these years (Speering & Rennie, 1996). From a researchers' point of view this contrast in findings raises the questions of whether the results of attitudinal research are dependent on *when* students are asked, as well as which perspective - cross-sectional or retrospective - is the most salient to students' enrolment decisions. Given that many policy initiatives concerning primary science education have been informed by findings from cross-sectional studies, it is important that these questions be resolved.

Factors likely to have contributed substantially to declines in enrolments

The evidence points to enrolment declines being due to an interrelated set of factors centred on students' responses to the changing context of subject choice for senior high school. The principal factor would appear to be greater number of options available to Year 11 students considering university study, resulting in increased competition among subjects for curriculum market share. Related to this systemic issue are three contributing factors more specifically associated with science education: the difficulty many students have in picturing themselves as scientists, a decrease in the utility value of some science subjects relative to their difficulty, and the failure of school science to engage more students.

Students' responses to increased curriculum competition

Around 45% of the science teachers considered the wide range of subjects available to students as having been very influential on the declines. The implication is that increased curriculum diversity has been drawing students away from science subjects, thereby reducing their market share. This proposition was not tested directly in Phase Two as it concerns long-term enrolment patterns rather than students' perceptions. Nevertheless, the evidence from enrolment data supports the teachers' opinions. A summary of national Year 12 enrolment trends by the Australian Council for Educational Research (ACER) shows that between 1993 and 2001 there was a significant shift in the curriculum market shares attained by a wide range of subjects (ACER, 2005). Figure 8.1 shows that the enrolment declines reported in Chapter 1 (Figure 1.1) were not limited to science subjects. Indeed, economics, accounting, geography and political/social studies appear to have experienced similar if not greater declines over this period. Data from other sources (Forgasz, 2006; McPhan, Morony, Pegg, Cooksey & Lynch (2008) indicate that the proportion of students enrolling in advanced mathematics courses also declined between 1995 and 2004.

These declines across the board suggest that other subjects must have been increasing their market shares over the same period. Figure 8.2 shows that subjects in the fields of business studies, secretarial studies, hospitality, computer studies, food and catering, music and performing arts and creative and visual arts all experienced substantial increases in enrolment share.

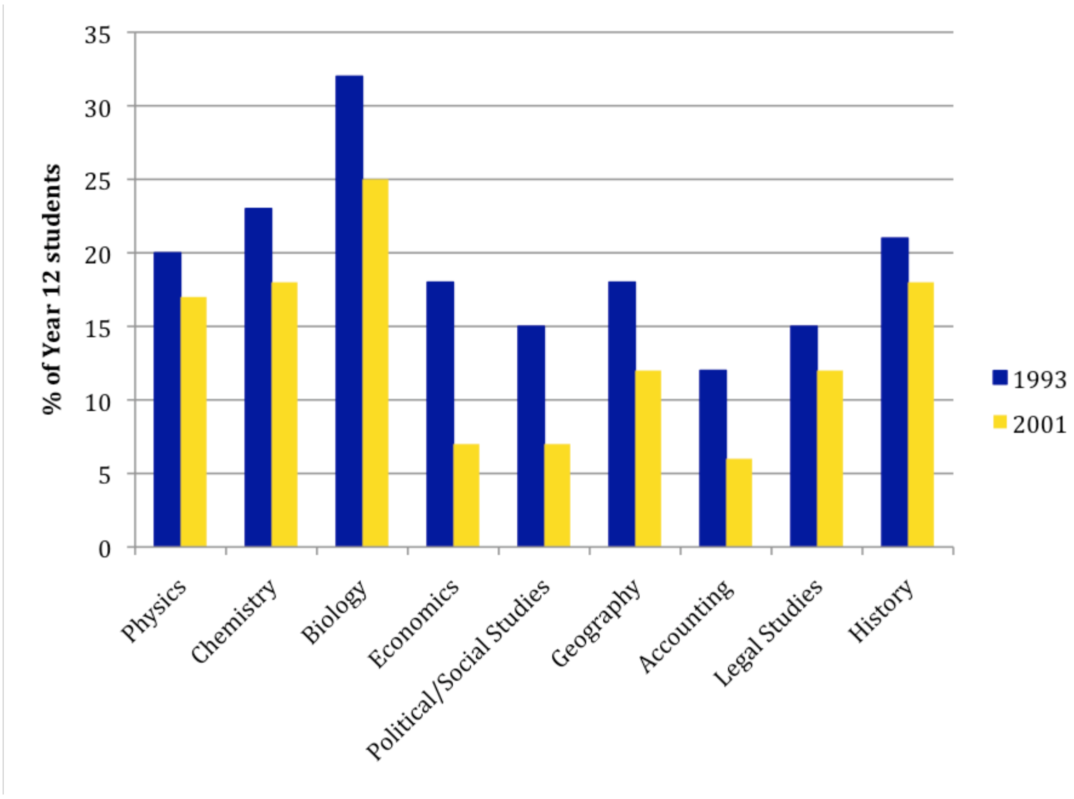

Figure 8.1: Year 12 subject areas experiencing a proportional decrease in curriculum market share between 1993 and 2001 (sourced from ACER, 2005)

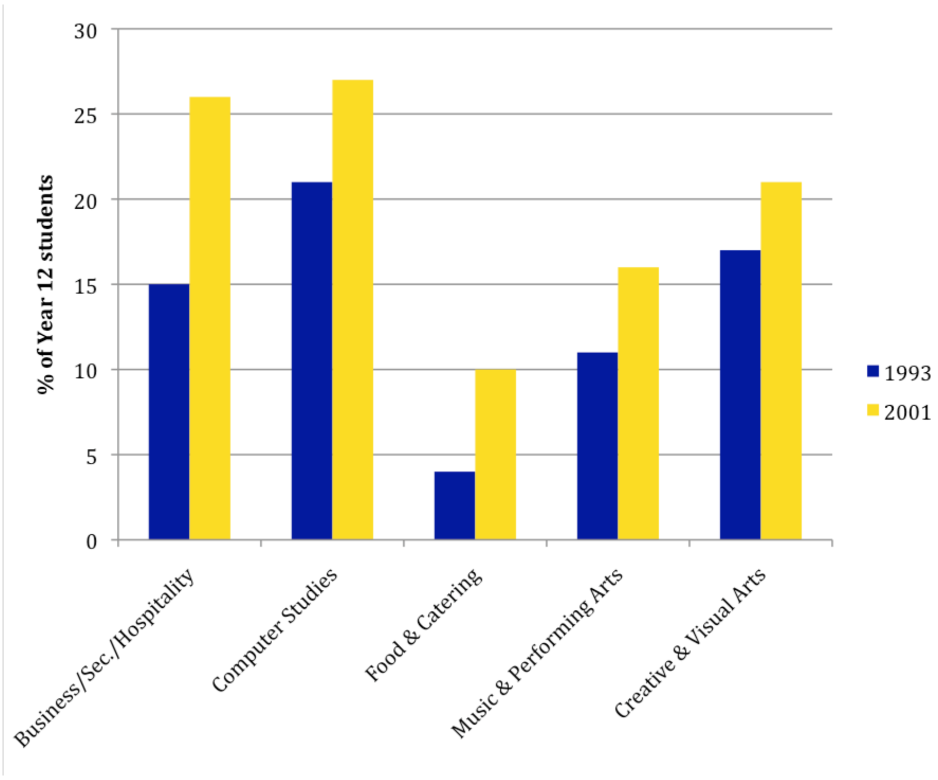

Figure 8.2: Year 12 subject areas experiencing a proportional increase in curriculum market share between 1993 and 2001 (sourced from ACER, 2005)

Unfortunately, comparable national data beyond 2001 are not available at this level of detail, and aggregation of recent enrolment data from individual states and territories is problematic due to different subject configurations. However, some indication of enrolment trends after 2001 can be gained by examining data from NSW, which has the highest number of Year 12 students in Australia.

According to the NSW Board of Studies, between 2001 and 2008 the proportions of Year 12 students taking Studies of Religion, Personal Development, Health and Physical Education (PDHPE), and Vocational Education and Training (VET) subjects all increased significantly, though computing/IT subject enrolments declined sharply after 2001. In 2008, around 20% of students were enrolled in Studies of Religion, a similar percentage took PDHPE, while approximately 24% took Business Studies. Around 30% of all Year 12 students in NSW were enrolled in a VET subject and around 24% undertook a VET subject in which the examination counted towards their tertiary entrance score (NSW Board of Studies, 2008). The increased participation in VET subjects reflects a national trend (ACER, 2008; NCVER, 2009).

It is important to recognise that many of the subjects increasing their popularity are not necessarily new offerings. However, two significant developments have altered the context for students' enrolment decisions. First, many subjects which previously were ineligible for consideration in university entry calculations are now eligible, making them more attractive options for university-oriented students entering Year 11. Second, universities have restructured their own curricula to cater for the larger numbers of high school students taking these subjects, offering degrees in tourism and hospitality management, sport science, sports management and business management, among others. These changes have in turn given a greater academic legitimacy and status to many school subjects previously considered to be non-university track subjects.

This discussion is not intended as a criticism of senior high school curriculum changes in NSW or elsewhere, which have been in response to increased student retention, career market evolution, changing student demographics, higher education policies and other influences. Vocational education in particular is considered one of the success stories of recent curriculum reform and has also contributed to improved student retention rates (ACER, 2008). Rather, it makes the point that the context and dynamics of subject choice have both changed dramatically, with traditional university-oriented subjects facing increased competition for curriculum share. Regardless of the merits or relative difficulty of particular subjects, it was perhaps inevitable that the market share enjoyed by long-established subjects like physics, chemistry and biology would decline with the introduction of more options. It may well be that science teachers and other stakeholders need to recognise that science subjects no longer have the privileged position they enjoyed previously, and that there is a need to respond by making science subjects intrinsically and strategically more attractive and rewarding to students.

Students' difficulties in identifying themselves as scientists

If we accept that contemporary students' deliberations about Year 11 subjects take place in the context of greater choice, then other factors become more critical. One of these is students' matching of career images with their own identities. The most common reason endorsed by students for not choosing science was that they were unable to picture themselves as scientists. One interpretation of this finding is that students are knowledgeable about science careers, but do not see a fit with their own aspirations. Alternatively, students may not have sufficiently well developed - or sufficiently authentic - images of scientists and science careers to use as reference points when attempting to picture themselves in various careers.

Evidence suggests that the second interpretation is the most likely. First, around 47% of science teachers in this study considered the enrolment declines to be due to students' lack of knowledge about the wide range of science careers available. They also strongly recommend the establishment of closer links with real scientists. Second, these opinions are supported by with findings from previous studies (e.g. Cleaves, 2005; Stagg, 2007) indicating that students lack an appreciation of the variety of science careers and authentic knowledge about what they involve. Finally, the multiple regression analysis revealed that students' responses to the item "school science has opened my eyes to new and exciting jobs" were a significant predictor of their intentions to pursue a science course at university.

This conclusion implicates a range of issues, including students' images of scientists, the significance of career role models, the impact of mass media images of careers, and the role of identity and self-image in students' choices (see Tytler et al., 2008 for a summary of these issues). The concept of students' identity construction in particular offers an explanation that fits well with the arguments around increased curriculum diversity, discussed above. It also involves a change dimension that may account for the enrolment declines. Australian students are today faced with a wider range of education options than at any time in the past, both at senior high school and university. Like young people in many developed countries, they are also more inclined than their predecessors to make choices based on a sense of personal identity (Bendle, 2003; Giddens, 1991; Schreiner, 2006). The combination of a broader and more-competitive curriculum marketplace and the need for students' aspirations to align with their sense of identity emphasises the importance of personal relevance and interest in students' decisions. This conclusion is also consistent with the high motivational value attributed to 'interest' among the students choosing science.

The increased priority given by today's students to career options that are personally meaningful and fit with individual constructions of identity emphasises the importance of providing them with opportunities to develop clear, authentic and relatable images of scientists and the work they do. This goal is particularly critical in the context of a competitive curriculum marketplace.

A decline in the utility of some science courses relative to their perceived difficulty

Two out of three science teachers considered students' preferences for less academically demanding subjects to have been very influential in the enrolment declines. The significance of subject difficulty was reflected to some extent in the explanations of students choosing no science, 45% of whom agreed that their decisions were due to science being more difficult than other subjects. Superficially, these findings might suggest that anticipated difficulty has been a strong factor in the enrolment declines. Certainly previous research has shown that students' deliberations about physics and chemistry are particularly sensitive to anticipated difficulty (e.g. Osborne & Collins, 2001; Lyons, 2006b).

However, anticipated difficulty alone falls somewhat short as a convincing explanation for the downward trend in science enrolments, as it lacks a change dimension. Physics and chemistry have long been considered relatively difficult subjects and there is no evidence to suggest that they have become more difficult over the last two decades. Indeed many science teachers would argue the opposite case (e.g. Burke, 2003). Further, no previous studies have linked anticipated difficulty with corresponding declines in biology enrolments. An alternative interpretation is suggested by the finding that two thirds of science teachers believe today's students to be more reluctant to persevere with repetitive or rigorous tasks, as required in science. This opinion shifts the focus from subject characteristics to student characteristics and suggests a change dimension; an increased reluctance among students to engage with modes of working fundamental to scientific endeavour. However, we contend that there is a third interpretation that is not only consistent with these findings but which also fits an emerging model of student choice grounded in similar studies. Rather than focusing on subject difficulty *per se*, this interpretation instead involves students' calculations of reward for effort, and how this relationship has changed over time.

The key to this interpretation lies in the significance of the term "relative". The opinions of science teachers and students reported above all include an element of relativeness and calculation: e.g. "less academically demanding subjects'; "more difficult than other subjects"; "more reluctant". We argue that this calculation involves students weighing the anticipated difficulty of science against the anticipated rewards, and comparing the outcome with similar calculations involving other subjects. In the terminology of Eccles and Wigfield (2002), we believe fewer students consider the utility value of physics and chemistry to be worth the relative cost value. Relative cost value concerns the negative aspects of a particular educational choice relative to alternatives. Examples of costs include cognitive effort, the amount of time invested or the potential implications of failure, such as lost opportunities, personal embarrassment or family disappointment. Utility value on the other hand includes the strategic benefits of completing the subjects. The utility value of physics and chemistry traditionally lay in their worth as prerequisites for many university courses, and to a lesser extent in the generally positive scaling effect they had on overall university entrance calculations.

Over the last two decades the utility value of physics and chemistry has become less tangible. Whereas either or both of these subjects were once considered prerequisites for entry to most undergraduate science courses, is now more common to see these subjects listed as 'assumed knowledge' or 'recommended studies'[36]. The relaxing of entry requirements has been an issue of much debate in universities and the media (e.g. Belward et al, 2007; Novak, 2009; Phillips, 2009), with the Australian Academy of Science identifying this as one of the key contributors to declines in mathematics enrolments at the senior high school level (AAS, 2006). At the same time, the relative utility values of other subjects have increased due to changes in university curricula and entry criteria, as discussed in the previous section. Shifts in employment fields have also influenced the relative utility values of particular subjects.

The influence of students' calculations of utility value and relative cost value was not investigated directly in this study. However, the arguments of teachers, the explanations of students and the trends in university entry criteria suggest this should be a focus for further research.

The failure of school science to engage more students

Given the preceding arguments, it would be tempting to blame the enrolment declines on systemic and social factors external to school science. However, several findings from *Choosing Science* suggest there is also a need to provide students with more engaging learning experiences. Many science teachers already recognise this need. Around 42% of teachers considered that negative experiences of science in junior secondary school had been very influential on the enrolment declines, while a similar proportion blamed a decrease in the amount of practical and experimental work being undertaken in class. Around 38% acknowledged that declines in the quality of science teaching were also a factor. The science teachers' principal recommendation for increasing enrolments was to make science lessons more exciting, enjoyable, interesting and relevant. A substantial number also recommended a more flexible curriculum to cater to a wider range of students.

Students' attitudes to school science were mixed. Around 45% agreed that science lessons were fun and one of the most interesting school subjects. While this is a generally positive result, the findings also revealed that a significant proportion of students is disengaged or disenfranchised by school science. Around a third indicated

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[36] Based on a review of University Admissions Centre guidebooks 1987-2009

they were bored by science lessons and over a quarter disliked science classes. In particular, students in rural and remote schools tended to enjoy science less than their peers in larger centres.

Previous research indicates that there has long been a significant number of students who were not engaged by the traditional curricula and pedagogy of school science (Ramsden, 1998). The TOSRA comparison also suggests there has been little change in students' attitudes towards school science over the years. In the context of a more competitive curriculum, however, this invariance is cause for concern. Given that many of the new or refurbished subjects mentioned earlier offer students fresh, innovative and engaging learning experiences, it is reasonable to ask whether more needs to be done to engage the disengaged in science education.

In view of the National Science Curriculum currently under development, it is clearly in the interest of science teachers and other stakeholders to improve the level of student engagement in junior science classes. The recommendations of teachers and students in this study should provide some indication of directions for this reform, along with recommendations from recent reviews (e.g. Fensham, 2006; 2009; Tytler, 2007).

What can be done to improve enrolments in senior science subjects?

There has been a great deal of speculation about the underlying causes of long term declines in physics, chemistry and biology enrolments. Increasing levels of concern have prompted education authorities, universities and science organisations to initiate a variety of interventions aimed at reversing these declines. The first step to developing effective policy to increase enrolments is to appreciate the complexity of interrelationships between systemic, societal, school and student factors associated with the declines. Because the declines have been strongly influenced by students' responses to systemic curriculum changes, it cannot be expected that interventions targeting teacher education, science syllabus development or better promotion of science courses and careers will result in these subjects attaining the same levels of curriculum market share they realised in the early 1990s.

Recommendation 1: That education authorities, science organisations and other stakeholders seeking to formulate policy to address declines in science enrolments take into consideration the findings of this study concerning the relative contributions of various factors to these declines.

The more competitive curriculum environment makes it critical that steps are taken to ensure school science is more engaging, inclusive and valued by students. The study identified several areas of science education that should be addressed in this respect.

Recommendation 2: That the Australian Curriculum, Assessment and Reporting Authority (ACARA), federal, state and territory education authorities and others relevant stakeholders ensure the new National Science Curriculum reflects teachers' and students' recommendations for increasing enrolments by making school science learning experiences more interesting, practical and personally relevant.

This recommendation is supported by the finding that 55% of students choosing no Year 11 science did so because they found junior high school science to be uninteresting. It is also consistent with science teachers' principal recommendation that the most effective strategy to encourage students to enrol in senior science is to ensure junior science classes are relevant, interesting and enjoyable. In particular, teachers' comments about the importance of contextualised learning and students' recommendations about more experimental/practical experiences should be taken into consideration.

Recommendation 3: That federal, state and territory education authorities, professional teacher associations and science organisations work together to develop adequately funded, sustainable and coordinated strategies to improve links between school science and scientists in university and industry settings. The strategies should have a particular focus on authentic, research-based science experiences both inside and outside the classroom and creating greater awareness among Year 10 students of the variety and scope of science-related careers.

Around two thirds of Year 10 students choosing no senior science made this decision principally because they could not picture themselves as scientists. Further, only 35%

of students considered that school science had opened their eyes to new and exciting jobs. The science teachers believed that students lack information about potential career paths, and strongly recommended the establishment of links to industry. In addressing this, existing programs such as *Scientists in Schools* or similar should be expanded, and measurable outcomes established. One possibility for exploration is that students who perform well in and enjoy science be given opportunities to proceed into alternative entry or accelerated higher education schemes.

Recommendation 4: That education authorities and universities ensure that the value of academically challenging subjects such as physics and chemistry (and indeed difficult non-science subjects) is adequately recognised in calculations of university entry scores/rankings and entry requirements across Australia.

Around 67% of science teachers believe that declines in science are due to students' tendency to choose less academically challenging subjects from the broad curriculum available. Implicit in this view is the belief that students weigh up the anticipated benefits and costs of taking subjects. In the context of the 'curriculum marketplace', one salient cost of taking physics and chemistry is their difficulty relative to many other subjects. Adequate and explicit recognition of this difficulty in university entrance calculations and requirements would go some way towards making these science subjects more attractive to students.

Recommendation 5: That science teachers should encourage girls to have greater confidence in their science learning and ability to achieve. Education authorities, professional associations and science organisations should continue working towards removing the barriers to participation by girls in some areas of science, and encourage initiatives to educate students about the range of opportunities available to women in science careers.

Because of perceptions that physics and chemistry are relatively difficult subjects, self-efficacy becomes an important consideration in students' decisions about these subjects. This study confirmed that Year 10 girls tend to have lower levels of self-efficacy than do boys and are therefore more sensitive to anticipated difficulty. Girls choosing no science were also significantly more likely than boys to attribute this decision to being unable to picture themselves as scientists.

Recommendation 6: That federal, state and territory education authorities and other stakeholders should carefully consider which stage of schooling represents the most cost-effective target for strategies aimed at improving and sustaining senior high school science enrolments.

Around 80% of Year 10 students believed their most recent experiences (Years 9 & 10) had the greatest influence on their decisions about taking senior science classes. Fewer than 8% of students believed their decisions were most affected by primary school experiences, and among those choosing science this percentage was even smaller. While acknowledging that students may not remember earlier influences or be aware of the cumulative effects of their experiences, the findings nevertheless challenge assumptions that targeting primary science education will result in more students choosing science in Year 11 (see also Recommendation 9).

Recommendation 7: That professional science teacher associations take steps to ensure their members are made more aware of the strong influence teachers have on students' decisions about choosing science.

The study found that while science teachers consider themselves to have less influence on students' decisions than peers and parents, Year 10 students believe teachers to be the most influential agents of all. This was particularly the case among students who chose Year 11 science. Science teachers need to be made aware that students are influenced by their attitudes and advice concerning Year 11 science subjects and careers paths.

Conclusions from the study also revealed a need to undertake further research in three areas:

Recommendation 8: Education authorities and other stakeholders should initiate further research to investigate why students in rural schools have less positive attitudes to school science than their city peers.

The study found that students in rural areas had significantly less positive attitudes towards science than those in larger population centres. They were also less inclined than city students to enjoy science more than other subjects. As these results are not represented elsewhere in the science education literature and no obvious explanation suggests itself, further research is required.

Recommendation 9: Education authorities and other stakeholders should initiate further research to investigate how school type (single sex or coeducational) affects Year 10 students' perceptions of their abilities in science.

The study found that boys in single sex schools tend to rate their abilities in science significantly higher than do boys in coeducational schools. However, a similar contrast was not found among girls in these school types. This curious and perhaps counterintuitive finding represents an avenue for further research.

Recommendation 10: Education authorities and other stakeholders should initiate further research to determine the influence of students' attitudes to science on their enrolment intentions, and in particular to clarify at what point students' attitudes are most salient to their decisions.

Students' in this study indicated that they enjoyed learning science more in Years 9 and 10 than in early secondary school, which they enjoyed more than in primary school. This finding is at variance with conventional thinking about developments in students' attitudes as they progress from primary to middle secondary years. The different results may be due to the different research methodologies employed. Given the influence of research findings on policy formation it is particularly important that this issue is further investigated and clarified.

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Appendix 1: Science teacher survey

Welcome to the Secondary Science Teacher Survey! We appreciate you taking the time to support this important study. It should only take about 5 minutes to complete.

Instructions: Please indicate your response to each question by clicking on the appropriate button. Some questions include space for additional comments if you have time.

A. About you and your school

1. In which state/territory is your school?	NSW ACT VIC TAS SA WA NT QLD
2. Which best describes your school type?	• Secondary to Year 12 • Senior secondary only • Junior secondary only • Combined primary and secondary to Year 12 • Combined primary and secondary to Year 10
3. Is your school …	• a government school? • a Catholic systemic school? • an Independent school?
4. Which best describes the location of your school?	• In a capital city • In a large non-capital city (population > 25 000) • In a rural city or large town (population between 10 000 and 25 000) • In a small rural or remote town (population < 10 000)
5. For how many years have you been teaching science?	• less than 5 years • between 5 and 10 yrs • between 10 and 15 yrs • more than 15 yrs

B. Your views about senior science enrolments The last fifteen years have seen substantial declines in the proportions of Australian students choosing senior physics, chemistry and biology courses. Several factors have been *suggested* as contributing to these declines.

How influential do you think the following *suggested factors* have been in contributing to the decline in science enrolments? (Please write any additional comments in the box at the bottom of this page)

6. The wide range of subjects available to senior students	Not at all influential, Not very influential, Moderately influential, Very influential, Extremely influential
7. A decrease in the number of units or courses needed to gain Year 12 credentials (e.g. HSC, ENTER, TER, etc.)	As above
8. A tendency for students to choose courses seen as less academically demanding	As above
9. A decrease in the number of units or courses needed to gain Year 12 credentials (e.g. HSC, ENTER, TER, etc.)	As above
10. A tendency for students to choose courses seen as less academically demanding	As above
11. A tendency to choose courses seen as more interesting/engaging than science	As above
12. A greater reluctance among today's students to persevere with repetitive or rigorous tasks, such as required in experimental work;	As above
13. Additional comments/examples?:	[Open response box]

14. Students' negative experiences of junior science classes	Not at all influential, Not very influential, Moderately influential, Very influential, Extremely influential
15. The junior secondary science syllabus or curriculum in your state/territory	As above
16. A decline in the quality of teaching in junior science classes	As above
17. A decline in the amount of practical and experimental work undertaken in junior science classes	As above
18. Additional comments/examples?:	[Open response box]
19. Students' perceptions that the effort required by physics or chemistry courses may not be suitably rewarded in the calculation of university entrance scores *(refers to physics and chemistry only)*	Not at all influential, Not very influential, Moderately influential, Very influential, Extremely influential
20. A decline in the standard of university entrance requirements/prerequisites	As above
21. Students' perceptions that science, engineering and technology (SET) careers are not sufficiently well paid	As above
22. Students' lack of knowledge about the wide range of SET careers available	As above
23. A perception among students that there is a low demand for SET jobs	As above
24. Additional comments/examples?:	[Open response box]
25. Students' perceptions that science can have a negative impact on society	Not at all influential, Not very influential, Moderately influential, Very influential, Extremely influential
26. A decline in the number of parents who encourage their children to take science courses	As above
27. The way the mass media depicts science or scientists	As above
28. A lack of effort from science organisations and university faculties to encourage students to choose senior science courses	As above
C. Sources of advice about choosing science **How do you rate the influence of the following on students' decisions about taking senior science courses?** (Please write any additional comments in the box at the bottom of this page)	
29. Careers advisors in your school	Not at all influential, Not very influential, Moderately influential, Very influential, Extremely influential
30. Parents and other adult relatives	As above
31. Advice from their science teacher(s)	As above
32. Advice from friends and peers in their year level	As above
33. Advice from older students or siblings	As above
34. Additional comments about Qs 29 – 33?	[Open response box]
D. Encouraging greater participation in science	
35. If you have noticed an increase in physics, chemistry or biology enrolments at your school over the last few years, please give your opinion about the reasons for this increase.	[Open response box]
36. Please list any extra-curricular programs or activities in which your school participates that	[Open response box]

encourage students to take senior science courses.	
37. Please describe any strategies you think would encourage more students to enrol in senior science courses (including successful strategies you have implemented or observed).	[Open response box]
If you were in a position to advise students about taking senior science courses, what advice would you give them about …	
38. …taking physics?	[Open response box]
39. …taking chemistry?	[Open response box]
40. …taking biology?	[Open response box]

Appendix 2. Year 10 Student Survey

ABOUT YOU AND YOUR SCHOOL	
1. Are you female or male?	Female, Male
2. Is your secondary school co-educational or single sex?	Co-educational Single sex
3. Which best describes your school type? (if you are not sure, please ask your teacher)	Government Catholic system Independent
4. In which state or territory is your school?	ACT, NSW, NT, QLD, TAS, SA, VIC, WA
5. Which best describes the location of your school?	In a capital city In a large non-capital city (population greater than 25 000) In a rural city or large town (population between 10 000 and 25 000) In a small rural or remote town (population less than 10 000)

YOUR EXPERIENCES OF SCHOOL SCIENCE	
6. Please indicate on the scale how strongly you agree or disagree with the following statements: "I like school science better than most other school subjects"	*ROSE item: 4/5 options from disagree to agree*
7. What I learn in school science helps me to make sense of the world.	Strongly agree, Agree, Unsure, Disagree, Strongly disagree
8. What I learn in school science makes me feel pessimistic (negative) about the future.	Strongly agree, Agree, Unsure, Disagree, Strongly disagree
9. How would you rate your own academic ability in science this year compared to others in your class?	Much better than average, Better than average, Average, Below average, Far below average
10. In which stage of your schooling did you *most* enjoy learning science?	Lower primary, Upper primary, Lower secondary, Middle secondary (Yrs 9 & 10)
11. Which stage of your schooling do you think had the greatest influence on your decision about whether or not to take senior science?	Lower primary, Upper Primary, Lower secondary, Middle secondary (Yrs 9 & 10)

WHAT YOU THINK ABOUT SCIENCE [TOSRA items]	
Please indicate on the scale how strongly you agree or disagree with the following statements. Don't worry if you find that several of the statements are similar - this is intentional. Just try to respond to each statement as honestly as you can. 12. Science lessons are fun 13. Money spent on science is well worth spending 14. Scientists usually like to go to their laboratories when they have a day off 15. I would dislike being a scientist after I leave school	Strongly agree, Agree, Unsure, Disagree, Strongly disagree

16. I dislike science lessons 17. Science helps make life better 18. Scientists are about as fit and healthy as other people 19. When I leave school, I would like to work with people who make discoveries in science 20. Scientists do not have enough time to spend with their families 21. I would dislike a job in a science laboratory after I leave school 22. Science is humankind's worst enemy 23. Public money spent on science in the last few years has been spent wisely 24. Scientists like sport as much as other people do 25. Working in a science laboratory would be an interesting way to make a living 26. Scientific discoveries are doing more harm than good 27. School should have more science lessons each week 28. Scientists are less friendly than other people 29. A career in science would be dull and boring 30. The government should spend more money on scientific research 31. I look forward to science lessons 32. Scientists can have a normal family life 33. I would like to teach science after I leave school 34. Too many school laboratories are being built at the expense of education 35. Science lessons bore me 36. Science is one of the most interesting school subjects 37. This country is spending too much money on science 38. Scientists do not care about their working conditions 39. A job as a scientist would be boring 40. Science can help make the world a better place in the future 41. Science lessons are a waste of time 42. Scientists are just as interested in art and music as other people are 43. I would dislike becoming a scientist because it needs too much education 44. Money used on scientific projects is wasted 45. I really enjoy going to science lessons 46. Few scientists have happy long term relationships 47. If you met a scientist, s/he would probably look like most other people 48. The material covered in science lessons is uninteresting 49. I would enjoy school more if there were no science lessons 50. A job as a scientist would be interesting 51. I would like to be a scientist when I leave school	
YOUR DECISIONS ABOUT SCIENCE FOR YEAR 11	
52. Which science courses (if any) have you chosen for Year 11 (you may tick more than one box) No science ☐ Physics ☐ Chemistry ☐ Biology ☐ Other science (please name) ☐	

54. If your 2008 subjects …. … include no science courses, click **here** [link to 'no science' questions] … include physics, click **here** [link to 'physics' questions] … include chemistry but not physics, click **here** [link to 'chemistry' questions] … include biology but not physics or chemistry, click **here** [link to 'biology questions] … include a science course **which is not physics, chemistry or biology**, click **here** [link to 'Other science' questions]	
[SECTIONS FOR PHYSICS/CHEMISTRY/BIOLOGY/OTHER SCIENCE SURVEYS ONLY] How influential were the following people in helping you decide about choosing …..? [physics/chemistry/biology/this science course]? 55. Mother: 56. Father: 57. An older sister or brother: 58. Close friends: 59. Older students: 60. Careers advisor: 61. Science teachers you have had in the last two years:	Very influential, somewhat influential, not very influential, not at all influential
How available were the following people to help you with your decisions about choosing science? 62. Mother 63. Father 64. An older sibling	Always available, often available, seldom available, never available
Please indicate on the scale how strongly you agree or disagree with the following statements. 65. I chose [physics/chemistry/biology/this science course] because I found science interesting in junior secondary school 66. I chose [physics/chemistry/biology/this science course] because I achieve good results in science 67. I chose [physics/chemistry/biology/this science course] because I had good science teachers. 68. I chose [physics/chemistry/biology/this science course] because I think it will be interesting. 69. I chose [physics/chemistry/biology/this science course] because I need it for university or a career 70. I chose [physics/chemistry/biology/this science course] because scaling will improve my university entry score. 71. I chose [physics/chemistry/biology/this science course] because my teacher encouraged me to do it	Strongly agree, agree, unsure, disagree, strongly disagree
[FOR NO SCIENCE SURVEY ONLY] How influential were the following people in helping you decide whether or not to choose a science course? 55. Mother: 56. Father: 57. An older sister or brother: 58. Close friends: 59. Older students: 60. Careers advisor:	Very influential, somewhat influential, not very influential, not at all influential

61. Science teachers you have had in the last two years:	
How available were the following people to help you with your decisions about choosing science? 62. Mother 63. Father 64. An older sibling	Always available, often available, seldom available, never available
[FOR NO SCIENCE SURVEY ONLY] Please indicate on the scale how strongly you agree or disagree with the following statements. 65. I chose no science courses because I find school science uninteresting. 66. I chose no science courses because I am not good at science. 67. I chose no science courses because I didn't have good science teachers. 68. I chose no science course because I don't need science for university or a career 69. I chose no science courses because of timetable/line clashes 70. I chose no science courses because science is more difficult than most other subjects. 71. I chose no science because I can't picture myself as a scientist	Strongly agree, agree, unsure, disagree, strongly disagree
SCIENCE AND YOUR FUTURE	
72. My year 10 teacher often discussed science careers with my class 73. I got most of my ideas about science careers from my parents 74. I got most of my ideas about science careers from the media and movies 75. I got most of my ideas about science careers from the school careers advisor 76. It is likely that I will choose a science-related university course when I leave school 77. I think science careers generally attract a high salary 78. I think it is fairly easy for a person with a university science degree to get a job in science	Strongly agree, agree, unsure, disagree, strongly disagree
79. Please indicate on the scale how strongly you agree or disagree with the following statement: 'School science has opened my eyes to new and exciting jobs'	*ROSE item: 4/5 options from disagree to agree*
80. If you could change one thing about high school science to encourage more students to choose it in Year 11, what would you change?	Expanding dialogue box

Appendix 3. Instructions for teachers coordinating *Choosing Science* - Phase Two

Before allowing students to access the survey …

1. Ensure you have permission from your Principal to participate in the study.
2. Check that you are able to connect to the *Choosing Science* survey from your school. The web address is www.simerr.une.edu.au/choosingscience. Please contact me on (02) 67732983 or at terry.lyons@une.edu.au if there is any problem with access.
3. Invite a class of Year 10 students (or all Year 10 students, it is up to you) to complete the survey. **All students continuing to Year 11 are eligible to participate, regardless of whether they have chosen a science subject.** Students who are not continuing to Year 11 should not access the survey.
4. Distribute the parental consent notes to eligible students.
5. Collect the signed consent notes and store in the Reply Paid envelope(s). Only students who have returned signed consent forms should be allowed to access the survey.
6. Arrange access for your class(es) to computers connected to the internet.

When students are ready to access the *Choosing Science* survey …

1. Each student should have individual access to a computer.
2. Read out the "Instructions to Students" (overleaf).
3. When you are satisfied that students have understood the instructions and are ready to begin, tell them the logon password, which is "chemistry" (lowercase).
4. They can then begin the survey. Teachers should be available for questions, however keep in mind that students' responses are confidential – they should feel that teachers cannot observe their answers.

After completion of the *Choosing Science* Survey …

1. Trials indicate that students take between 15-25 minutes to complete the survey. This means some will be finished before others. It is up to individual teachers how they wish to accommodate this.
2. If your students uncover a problem with the survey, please contact me as soon as possible.
3. The signed parental consent forms can be returned to UNE in the Reply Paid envelope(s).
4. Finally, in the table below please write the names and contact details of the science teachers who helped coordinate the Student Survey in your school.

……………………………………………………………………………………………

…………………………..

<table>
<tr><td colspan="2">Name of School:</td><td>State/territory</td></tr>
<tr><td>Name(s)</td><td>Email contact</td><td>Phone contact</td></tr>
<tr><td></td><td></td><td>( )</td></tr>
<tr><td></td><td></td><td>( )</td></tr>
<tr><td></td><td></td><td>( )</td></tr>
<tr><td></td><td></td><td>( )</td></tr>
</table>

Instructions for Students

(To be read out to students by coordinating teachers prior to logging on to the survey)

1. "Thank you for agreeing to participate in the *Choosing Science* survey. By completing the survey, you will be helping the Australian Science Teachers Association and SiMERR Australia understand students' decisions about whether to take senior science courses.

2. "The survey should take about 20-25 minutes to complete. If you have any problems or questions, please raise your hand and your teacher will help you.

3. "Please be as honest as you can in answering questions. Take your time to think carefully about your experiences of school science so far, and how you went about making your subject choices for next year.

4. "You may find some of the questions a bit repetitive. This is intentional – please be patient and answer each as honestly as you can.

5. "Your answers will be anonymous and confidential. No teacher, principal or education authority will have access to your responses,

or be able to identify you from your answers. No student or school will be named in any reports.

6. "If you wish to see the results of the survey, a summary of findings will be available on the SiMERR website.

7. "To access the survey now, go to www.simerr.une.edu.au/choosingscience.

8. "If you have further questions, there is more information about the survey on the webpage sidebar menu.

"To begin the survey, click on 'Choosing Science' and then enter the password 'chemistry'