Science and Mathematics Education Centre

The Influences of a Program of Enrichment and Extracurricular Activities on the Affect of Secondary Science Students

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To my Family

ABSTRACT

A quasi-longitudinal case study was used to determine the effects on secondary students of participation in a program of enrichment and extracurricular science activities in terms of their interest and enjoyment in being involved in science activities, their motivation to continue to participate in science, and their perceptions about scientists and about the role of science in society. Two groups of students in a school were followed simultaneously, a junior cohort through Years 8 to 10 and a senior cohort through Years 10 to 12. Both qualitative and quantitative data were collected from 20 students; five girls and five boys from each cohort. A strong positive relationship was found between changes in students' interest and enjoyment and changes in their motivation, and both these variables increased, in an overall sense for the combined student population, during the study period. All students generally held a high perception of both the normality of scientists and the importance of science in society throughout the study period. Participation in science activities impacted overall positively, but to varying extents for different activities, on all four dependent variables. Suggestions for the structure and/or conduct of competitions, excursions, and practical work, including the design of museum exhibits, and implications for further research are presented.

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CHAPTER 1

Introduction to the Study

1.1 Overview of the Study

At the beginning of this study in 1991, a broad range of enrichment and extracurricular science learning experiences was being offered to students at Glendale College[1], and more were being introduced. These on- and off-campus activities included competitions, excursions, guest evenings, practical investigations, an explainer program, Science Club, work experience, and lectures, vacation schools, and seminars.

The term *enrichment* is used in this study to describe learning experiences which are perhaps novel due to their low frequency, are undertaken by all students taking a particular course of study, and are additional to the basic curriculum as outlined by the State science syllabi. In contrast, learning experiences associated with syllabus requirements (e.g. field work in Senior Biology) tend to be more routine and are likely to be similar to those in other schools. The term *extracurricular* is used to describe those activities which are available to students on an optional basis. With the exception of Science Club, extracurricular activities take place outside formal timetabled lessons and there is no compulsion for any student to participate.

The primary aims of providing these enrichment and extracurricular opportunities at Glendale College were to motivate students to continue their participation in science and to promote an understanding of the importance of science. At the same time, many of the activities provided practice in some of the processes of science. Different types of learning experience were deliberately represented in the total program, based on the premise that different experiences are likely to have different effects on the affect of different students.

This study investigates the effectiveness of the enrichment and extracurricular activities. A quasi-longitudinal case study approach was used to explore the influences of participation in the program in terms of students' interest and enjoyment in being

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[1]Glendale College is a pseudonym.

involved in science activities, their motivation to continue to participate in science, and their perceptions about scientists and about the role of science in society.

1.2 Context of the Study

The College

Glendale College is an independent, coeducational, day and boarding school situated in a rural Queensland city with a population of around 10 000 predominantly white Australians. There are four other secondary schools in the city. At the beginning of the study period, the College catered for primary students in Years 5 to 7 and secondary students in Years 8 to 12, with the introduction of lower primary classes planned during the forthcoming years. Secondary student enrolments steadily declined from about 332 to about 276 during the study period, which coincided with a period of rural recession. During this time, the overall College male-to-female ratio remained relatively constant at about 1.3:1. Senior students (i.e. Years 11 and 12) accounted for slightly less than one half the secondary population each year, with junior students (Years 8 to 10) comprising the remainder. On average, approximately 80% of Year 10 students proceeded to Year 11 each year.

The vast majority (70-85%) of secondary students at each year level were boarders who came from diverse locations which included rural Queensland and Northern New South Wales, metropolitan areas, and, to a lesser extent, Asian countries. The academic abilities of secondary students covered a broad range.

The typical age of entry into Year 8 at the College was the year in which a student turned 13 years. All students studied the same Year 8 science course and then studied either Science or Science for Living during Years 9 and 10. The latter was intended to provide for the needs of lower-aptitude students. During their senior years, students could choose to study any one or more of the subjects Biology, Chemistry, and Physics, and these subjects were taken by 37%, 28%, and 27% of students respectively. The male-to-female ratios in these subjects were approximately 0.8:1, 1.9:1, and 3.1:1, respectively. These enrolments were broadly typical of data for Queensland as a whole (Beasley, Butler, & Satterthwait, 1993).

Science classes at the college were taught by four experienced caucasian teachers (two male and two female), two of whom originated from overseas and had overseas teaching experience.

The National Climate

The enrichment and extracurricular learning experiences providing the focus for this study are being made available to students at a time when our national climate is characterised by the need for more graduates with a background in science and technology and a generally negative perception by the population of science and scientists. There is abundant evidence that Australia has a shortage of people skilled in mathematics, science, and technology which is increasing rather than diminishing (Willis, 1990; Wright, 1993), and the same applies to other countries (Misiti, Shrigley, & Hanson, 1991). The Australian Science and Technology Council (ASTEC) (1991b) predicted major shortages of appropriately qualified researchers and technologists hindering Australia's ability to raise its research and development effort. Further, it is difficult to attract good-quality science students (Australian Academy of Science, 1991; Fensham, Corrigan, & Malcolm, 1989; Leech, 1991; Lowe, 1993b; Mulroney, 1993) and Penington (cited in O'Neill, 1989, p. 10) predicted that "the crisis is going to bite progressively during the next decade, the very time we must make big advances in the technology capacity of industry."

As well as a shortage of practising scientists and technologists, the *Study of the Labour Market for Academics* (cited in Johnson, 1991) found that, in a climate where the demand for academics will soar in the next decade, one of the biggest shortages will be for trained academics in the sciences. Increased future employment opportunities in a wide range of science-based careers have also been predicted (*Australia's Workforce in the Year 2001*, cited in Coomber, 1991; Brennan, 1990; Free, 1993).

The need to attract more people to science is exacerbated by the public's generally poor image of science and scientists. Compared to countries like Sweden and Japan, which have enjoyed strong economic growth based on the application of science, mathematics, and technology and whose population is aware of the cultural role of science, mathematics, and technology (Willis, 1990), the recent OECD Examiners' Report on Science Policy in Australia drew attention to the widespread view in Australia that science and technology are external to most people's lives and of interest to a specialised, and predominantly male, minority (H. Allnutt, personal communication, September 23, 1991). Various writers have reported the poor perceptions among young Australians of scientists, careers in science, and the relevance of science to society and the future (Cribb, 1991a, 1991b, 1991c; Department of Industry, Science & Tourism, 1996; Kahle, 1989) and as then science minister Free (cited in Cribb, 1991a, p. 5) said, "science could never make a full contribution to the nation while such attitudes prevailed." This is happening at a time when, more than ever before, the critical importance of science and technology to Australia's future well-being is recognised (Cook, 1994) and Australia's future depends on the wider community's appreciation and understanding of science (Department of Employment, Education, and Training, 1992). Fortunately, there appears to be some cause for optimism. Based on the results of the Second International Science Study, Rosier and Banks (1990) reported that 10-year-old and 14-year-old Australian students had a generally positive view about the role of science in society and there was increased acknowledgement by Year 8 and 9 students, between 1991 and 1994, of the importance of science and technology to Australia (Woolcott Research Pty Limited, 1995), with television appearing to have played a significant role in this trend (Lowe, 1993c; Woolcott Research Pty Limited, 1995). Also, 18- to 24-year-olds have recently seen a major role for science and technology in Australia's future and in shaping the world (Department of Industry, Science & Tourism, 1996), although the source of data for this conclusion is not given.

The problems of negative perceptions about science seem especially to affect the participation of females in the sciences, who tend to have less positive attitudes towards, and lower participation rates in, science than males (Clifton, 1993; Dawson & O'Connor, 1991; Dekkers & de Laeter, 1997; de Laeter & Dekkers, 1998; de Laeter, Malone, & Dekkers, 1989; Dibben, 1992; Godfrey, 1993; Jones, 1994; Rosier & Banks, 1990), and a similar situation has been reported in other countries (Tamir, 1994; Weinburgh, 1995). Despite a number of initiatives aimed at encouraging the further participation of females (West & Leech, 1991) and some significant progress in this area (Connelly & Cribb, 1992) in Australia, females continue to be under-represented in mathematics, engineering, the physical sciences, and doctoral science studies (ASTEC, 1991a; Lowe, 1993a; Statham, 1996; West & Leech, 1991).

1.3 Research Questions

There is a need in Australia for more people to be involved in science and to increase the understanding and appreciation of the broader community about the role science plays in society. However, the interest and enjoyment of students in being involved in science activities is an important factor in determining their further participation in science. The interest and enjoyment of Australian students is decreasing between upper primary school and lower secondary school, the latter being a critical time for students' decision-making about continuing to study science. In addition, negative perceptions about scientists and about the role of science in society are likely to curtail the further participation of students in science and may be a detrimental influence on, for example, the future decision-making of students when they take their role as voting citizens of the nation.

Hence, it was important to evaluate the effectiveness of enrichment and extracurricular learning experiences, such as those offered at Glendale College, in developing appropriate attitudes. Thus, this study is concerned with the influences of the program of enrichment and extracurricular science activities on students' affect, defined as the students' interest and enjoyment in being involved in science activities, their motivation to continue to participate in science, and their perceptions about scientists and about the role of science in society. Specifically, three questions will be answered in this study.

1. How do students' interest and enjoyment in being involved in science activities, their motivation to continue to participate in science, and their perceptions about scientists and about the role of science in society change over the period of the study?
2. Why do these variables change during this time?
3. What effects does student participation in enrichment and extracurricular activities have on these variables?

1.4 Overview of Method

The quasi-longitudinal research approach adopted involved simultaneously following two cohorts of students through 2.5 years of secondary education; the first cohort from the middle of their Year 8 to the end of Year 10 and the second from the middle of Year 10 to the end of Year 12. A range of data was collected from a sample of students within each cohort. As a result of attrition, the composition of the two student samples varied during the study period. However, information was collected in such a way that the final analysis of data involved 10 students (five girls and five boys) from each cohort; 20 students in all.

The focus of this research is how and why students' interest and enjoyment in being involved in science activities, their motivation to continue to participate in science, and their perceptions about scientists and about the role of science in society change during the study period. Each of these variables is defined primarily in terms of each student's intuitive definition of the variable, as they responded to written survey items and questions during interviews. During interviews, the researcher offered some alternative terms in order to elicit further responses from students. The interview process is described fully in chapter 3.

In an effort to triangulate the data, a number of additional survey instruments with a traditional format were also employed. These instruments comprised five of the seven scales from the Test of Science-Related Attitudes (TOSRA) (Fraser, 1981) and a five-statement Course Interest Survey adapted from Burr (1985). The TOSRA scales used were Scale S, Social Implications of Science (a measure of attitude towards the social benefits and problems which accompany scientific progress); Scale N, Normality of Scientists (a measure of an appreciation that scientists are normal people rather than the eccentrics often depicted in the mass media); Scale E, Enjoyment of Science Lessons; Scale L, Leisure Interest in Science; and Scale C, Career Interest in Science.

While these survey instruments were the most appropriate available, they often tend to define a dependent variable operationally in a different, and more restrictive, way than do students. For example, TOSRA Scale E items and the Course Interest Survey focus on a student's interest and enjoyment in science lessons, and this is only one aspect of their interest and enjoyment in participating in science activities in general. A student could have a very high overall interest and enjoyment in science (possibly, for example, as a result of their activities in a science club or other extracurricular activity) yet find their interest and enjoyment of school science lessons low because of the pedagogical approach adopted by, or a personal conflict with, a particular teacher. TOSRA Scales L, C, and N, and to a lesser extent Scale S, are similarly restrictive and the nature of the restrictions is expanded in chapter 3.

The need for students to use definitions of variables, such as interest and enjoyment, with which they were comfortable, and the more restricted definitions from the survey instruments introduce a possible complication into the analysis of data. Further, because the study is longitudinal, students' ideas and perceptions change as earlier memories fade or are re-interpreted. This complication was dealt with during data analysis by giving appropriate recognition to data representing the fullest and latest perceptions of students. The more restricted but consistent definition of variables in the survey instruments is especially useful in monitoring changes in the dependent variables. Thus the different kinds of measurement of these variables provide opportunities for data triangulation.

Both qualitative and quantitative data were collected, some from every student in each study cohort and some from sample students only. Qualitative data comprise annual end-of-year interviews, a written survey to determine students' reasons for choosing to participate or not participate in extracurricular activities, written records, and observations. The written records include information about student participation in science activities and demographic data about students. Observations pertain to student engagement in science activities, the response of organisers to competitions, and information about students originating from staff meetings and administration memos. Quantitative data comprise three annual surveys; a Rating Scale survey in which students rated their interest and enjoyment, their motivation, and their view of the importance of science in society, and results from the TOSRA and the Course Interest Survey.

The data are analysed in three phases. Phase 1 involved summarising in case study format, for each of the final 20 sample students, how and why their interest and enjoyment in being involved in science activities, their motivation to continue to participate in science, and their perceptions about scientists and about the role of science in society changed during 2.5 years of secondary education and what effects participation in enrichment and extracurricular activities had on these variables. In Phase 2, each of the dependent variables was considered in turn. Data from all 20 sample students were used in a search for generalisations relating to changes in each variable, including how and why they changed. During Phase 3 of the analysis of data, each enrichment and extracurricular science activity was considered in turn in terms of its effect on each dependent variable.

1.5 Significance of the Study

Some commentators have questioned the value of activities like those which are the focus of this study. Swartz (1996), for example, suggested "maybe the novelty and excitement [of a hands-on science museum visit] will inspire some student visitors and leave them wanting to learn more . . . . Maybe. But we seldom find out. There is almost no assessment of the outcomes of museum visits" (p. 200). As will be seen in chapter 2, overall there has been little research involving the affective outcomes of enrichment and extracurricular science activities and many of the learning experiences focussed upon in this study have never been the subject of structured research. Further, nearly all of the studies reviewed have been concerned with the short-term affective outcomes of participation in individual activities only, where short-term effects are distinguished from longer-term ones which, in accord with Arzi (1988), are present about one year or longer after participation in an activity. Also, those activities organised by the school have not been evaluated in the school context. There appears to have been no attempt to study the influences of participation in activities by means of a longitudinal design.

By providing data to answer questions about the value of enrichment and extracurricular science activities in achieving affective outcomes, this study will assist science educators in their cost-benefit analysis of the potential inclusion of such activities in school curricula. Teachers devote much time to planning these learning experiences and their implementation is often accompanied by significant costs such as transport and time during which students are removed from other classes and hence denied an opportunity to be exposed to alternative learning experiences. If significant gains cannot be shown to accompany these non-mandatory activities, their inclusion in a secondary science curriculum would be difficult to justify. Teacher and student time, as well as associated expenditure, may be better directed to other needs.

In particular, the study explores the potential for such activities to contribute to the nation's need for further participation in science, the filling of perceived employment opportunities, and improved community perceptions about scientists and the role of science in society. A positive contribution by science activities in these areas would assist in maximising the contribution of science and technology to Australia's social and economic well-being.

1.6 Structure of the Thesis: An Overview

The next chapter of this thesis contains a review of literature relevant to the research, and includes sections dealing with each dependent variable, the effects of enrichment and extracurricular science activities on these variables, the effects of the structure of an activity on outcomes from it, and the need for further research. In chapter 3, the research design employed in the study is described and discussed.

Chapters 4 and 5 report and analyse the data for the junior cohort of students and chapters 6 and 7 present results for the senior cohort. Chapters 4 and 6 document case studies for students in the junior and senior cohorts respectively, while chapters 5 and 7 synthesise the findings and address the research questions for each cohort. Finally, chapter 8 contains a summary of the study, together with conclusions and implications for teaching and further research.

CHAPTER 2

Literature Review

2.1 Introduction

This literature review is presented in seven parts. In sections 2.2 - 2.5, the research literature pertaining to some general aspects of each dependent variable in this study (students' interest and enjoyment in being involved in science activities, their motivation to continue to participate in science, their perceptions about scientists, and their perceptions about the role of science in society) is summarised. In section 2.6, the documented effects of participation in enrichment and extracurricular science activities on students' attitudes, as represented by these dependent variables, is reported.

The outcomes for students from participation in an enrichment and extracurricular science activity can depend upon the manner in which the activity is structured, and section 2.7 contains a synthesis of literature results pertaining to the effective structuring of such activities. Finally, in section 2.8, the findings of this literature review are overviewed and the need for a study such as this is emphasised.

A Comment About the Science Education Literature

The science education literature about attitudes towards science includes many studies in which the attitudes constituting the dependent variables are either not defined or are measured using the total score obtained by adding the scores from items representing different constructs. Others have noted such shortcomings (Gardner, 1996; Lederman, Gess-Newsome, & Zidler, 1993). In various studies, the term *attitudes towards science* has included attitudes towards science lessons, science teachers, scientists and their traits, the role of science in society, achieving highly in science, ability to achieve in science, the methods of science, leisure pursuit of science, continuing to study science, a career in science, or specific science issues such as the use of nuclear energy. Unless the attitudes being measured are clearly defined, a study produces data which are rather meaningless for the purpose of synthesising the research reported in the literature.

James and Smith (1985), for example, report an overall decline in Kansas students' attitudes towards science particularly as they move from Year 6 to 7, where students' attitudes are described as a combination of attitudes towards science as a school subject and attitudes towards science-related employment. Both constructs are potentially very broad, neither is defined, and the nine and four (respectively) Likert-type items used to measure them are not described.

Ignatiuk (1978) used a 60-item questionnaire to study the effect of field trip activities on students' attitude towards science. The items covered concepts such as students' enjoyment in studying science and using science knowledge in some scientific field (the same item!), the nature of science and scientists, the difficulty of science, the capacity of science to answer all questions, the ability of members of the community to understand science, and the workload of scientists. Because the results from each item were combined, the conclusion of the study is less useful than if conclusions had been based on the separate constructs derived from an appropriate grouping of items. Similarly, in studying the change in motivation of Iranian students in science during their middle-school years, Aiken (1979) combined items representing motivation towards continuing to study science with motivation to work hard in science classes; two distinctly different constructs. By relating achievement in science courses to a potpourri of attitude constructs exemplified by such diverse items as "I really enjoy science," "I think scientists are neat people," and "Everyone should learn about science," the study of Gooding, Swift, Schell, Swift, and McCroskery (1990) is limited in its contribution to the understanding of any link between attitude and achievement.

Mallon and Bruce (1982) studied the effects of two different types of planetarium programs on the attitudes of 8- to 10-year-old students about astronomy. Once again, the 20-item Likert-scale opinionnaire used to measure attitudes contained a potpourri of items including the difficulty a student experienced in reading about astronomy, the amount of learning they achieved in astronomy during the year, the match between what they had done and what a real astronomer would do, their liking for astronomy classes, the enjoyment their friends experience doing astronomy, the relevance of their astronomy studies to life outside school, their motivation to take further science classes, and the degree of importance of class experiments. Even reviews like those of Schibeci (1984) and Husen and Postlethwaite (1985), which conclude that student attitudes to science decline with increasing grade level, have reduced usefulness because the conclusions cannot always be based upon a clear definition of the attitudes involved. In this review, attention is paid to the definitions of the attitudes being measured and an attempt is made to evaluate the contribution of a study in terms of its clarity of definition and strength of methodology.

2.2 Interest and Enjoyment

Trend With Time

The consensus of the literature is that the interest and enjoyment in being involved in science activities of not only Australian students, but also of students in other countries, declines between upper primary school and lower secondary school. Baker and Piburn (1991) even reported a decline in ninth-grade students' desire for science, the value they place on science, and their wish to pursue science any further in circumstances where the curriculum had been subjected to innovation and the content and process achievement of students was improving.

Baird, Gunstone, Penna, Fensham, and White (1990) used questionnaires (apparently extended-response, although both this and the number of items on the questionnaires are not specified) in six surveys of over 2000 Years 7 - 10 students at three schools (presumably in Victoria, Australia, although this is also not specified) over a 3-year period to conclude that the levels of students' interest in, application to, and enjoyment of, science diminished sharply after Year 7. No information is given about the proportion of the data which is of a follow-up, as opposed to a cross-sectional, nature although the fact that the six surveys conducted involved only four year levels suggests that their conclusion was based upon at least some follow-up data. In a less extensive survey, they found a similar decline in attitude from Year 6 to Year 7, with more girls than boys disenchanted with Year 7 science.

Rosier and Banks (1990) reported the results from the Australian component of the Second International Science Study, a comprehensive examination of science education in 24 countries. The data from an opinion questionnaire administered to two different student populations (4259 10-year-old Years 4 to 6 students from 220 schools and 4917 14-year-old Years 8 to 10 students from 233 schools) representing government and non-government schools in all Australian States and Territories showed that students tended to enjoy the science they learned at school more at the primary than at the secondary level.

In a survey of 1442 Year 5 (from 71 schools) and 1223 Year 9 (from 60 schools) students from Victorian schools representative of the various types and sizes of school in the State, Adams, Doig, and Rosier (1991) used two questions (each requiring a *yes*, *no*, or *uncertain* response) on a five-question survey in each of five science topic areas to conclude that Year 5 students in 1990 had a greater interest in learning more science than Year 9 students. In Western Australia, Speering and Rennie (1996) used an attitude survey with 71 Year 7 students and 147 Year 8 students the following year (their first year of secondary school) to conclude that students' interest in, and enjoyment of, science declined during transition from primary to secondary school. Again, the girls became less interested in science than the boys.

A similar decline in students' interest in being involved in science has been reported in the United States (Barrington & Hendricks, 1988; Hofstein & Welch, 1984; Piburn & Baker, 1993; Yager & Yager, 1985). Interestingly, Barrington and Henricks (1988) found no difference between girls and boys in changes in attitude to science classes (including fun, level of interest, degree of excitement, comfortableness, and curiosity associated with science classes) between Years 3, 7, and even 11.

The studies of Piburn and Baker (1993) and Speering and Rennie (1996) are particularly useful because, in addition to documenting the trend in interest in science (the best that can be achieved by a comparison of attitude scale scores), their methodologies elicited reasons for the trend. These reasons included the growing abstraction, complexity, and difficulty in understanding science, a decline in both academic and social student-student and student-teacher interactions, increasing uncomfortableness with open-ended activities as opposed to achieving a single correct result, and disenchantment with the teaching strategies used in secondary science classrooms. Smith (1988/1989) identified teacher characteristics as another contributing factor.

However, this general trend in interest needs to be qualified. First, the trend in a student's interest and enjoyment in being involved in science activities may vary according to the aspect of science being considered. For example, although Kelly (1988) found that the liking for science among girls declined between the first and third year of secondary school, this decline did not hold for learning about human biology. Further, Adams et al. (1991) found that of five science topic areas, Light and Sound and Force and Motion were considered by both Year 5 and Year 9 students to be the least appealing topics, with girls more interested than boys in Life and the Environment and boys more interested than girls in Force and Motion. Hence, how students perceive their interest in science at a particular point in time is likely to depend upon their vision at that time of what constitutes science.

Second, the trend might also vary with the type of student. For example, Simpson and Oliver (1990) found the decline in attitude toward science (including a potpourri of constructs) of Years 6 to 10 students greater for middle-ability students than others. Barrington and Hendricks (1988) reported a much larger positive change in attitude towards science classes between Years 7 and 11 for gifted students than for average students, although the fact that science in Year 11 was studied only by students who chose to do so compared with a broader enrolment in Year 7 may have contributed to the overall positive trend. Further, Hofstein, Maoz, and Rishpon (1990) concluded that although Year 11 Israeli students found science studies less interesting than Year 8 students, no such difference was observed in students who enrolled in extracurricular science activities conducted at universities during the interim. Similarly, this may be because the students who enrolled in these activities were the students who were most likely to have an interest, including a continuing interest, in science.

Link With Achievement

In accord with the conclusion of Mehrens and Lehmann (cited in Swee, 1985), any relationship between interest and enjoyment in science and achievement of students during their compulsory science years appears to be at best mildly positive but lacking in any predictive value. Rennie and Punch (1991) found the link between attitude to science and achievement in science to vary with the attitude involved. In addition, these authors suggested that the strength of such a relationship may depend upon how student achievement is measured, with school-based achievement (used for grading purposes and, as a result, affecting students' perceptions of their competence in science) likely to be more positively correlated than standardised achievement test results which may not be reported to students or be used for grading purposes.

Comber and Keeves (cited in Gardner, 1975) cite data obtained from 17 countries (although the nature of the achievement data is not specified) to report correlations between science interest and total science test score for 14-year-olds mostly around 0.2 - 0.3 (indicating a very low relationship) but much higher (0.4 - 0.6) at the terminal year of secondary school. As Gardner (1975) points out, a stronger relationship might be expected at higher year levels when many students have opted out of science and the ones continuing to participate are perhaps the more scientifically able and interested. This may be the case in the studies of Kempa and Dube (1974) and Tamir (1989), which report strong correlations between student interest in science and achievement of secondary chemistry students and between the interest and motivation of twelfth-grade students in science and their achievement, respectively.

Oliver and Simpson (1988) used Likert-scale interest items and the school grades of 5000 North Carolina students in Grades 6 to 10 to conclude that interest in science was not usually a powerful predictor of achievement. Rennie and Punch (1991) similarly used Likert-type items to conclude that there was little significance in the relationships between the enjoyment and enthusiasm in science of 390 Year 8 Western Australian students and their subsequent achievement, although these attitudes were more closely related to previous achievement. While these authors hypothesised that these variables were interactive, the results tend to suggest that achievement is more likely to affect attitudes than attitudes are to affect achievement.

2.3 Motivation

Link With Interest and Enjoyment

There appears to be a strong positive relationship between students' interest and enjoyment in being involved in science activities and their motivation to continue to participate in science (Hasan, 1975; Mason & Kahle, 1988; Piburn & Baker, 1993), with Adams et al. (1991) reporting Year 9 Victorian students to be less favourably disposed towards a science career than Year 5 students, a trend which parallels their finding about the corresponding decline in students' interest in learning more science. Even more significantly, interest and enjoyment appears to be an important factor in determining the further participation of students in science (Fensham et al., 1989; Hofstein, Maoz, & Rishpon, 1990; Khalili, 1984/1985; Pollack, 1981/1982; Rennie & Parker, 1991).

Influences on Motivation

The influences on the subject choices and career paths of students are highly complex (Dawson & O'Connor, 1991) and were categorised by Woods (1979) as affective and utilitarian in nature. Whereas affective influences involve students' feelings (e.g. like/disliking) and preference to adopt particular attitudes, utilitarian influences concern practical or material things (e.g. career and ability) and emphasise usefulness rather than feelings. Affective influences include interest and enjoyment in studying a subject (Cameron, 1989; Dekkers, de Laeter, & Malone, 1986; Wood & de Laeter, 1986), closeness of a student self-image to the stereotypical image of a scientist (Brush, 1979), educational environment (such as science laboratories and libraries [ASTEC, 1991a]), perceptions of industries and industry sectors (ASTEC, 1991a), view of science as a career (Australian Council for Educational Research, 1989), and influence of teacher (Robinson, 1991; Swartz, 1992; Wood & de Laeter, 1986).

Utilitarian influences include a number of career-oriented factors, as well as achievement (ASTEC, 1991a; Crawley & Black, 1992; Gruzalski, 1996), subject choice options (Dekkers et al., 1986; Wood & de Laeter, 1986), relative difficulty of subjects (Dekkers et al., 1986), level of salaries (ASTEC, 1991a; Australian Academy of Science, 1991; "Time to tally," 1996), different costs of obtaining different degrees (Anderson, 1996; Lowe, 1996a; Pockley, 1996), influence of parents and peers and perception of own ability (Wood & de Laeter, 1986), knowledge and experience of work situations and parental opinion (ASTEC, 1991a), lack of information about career paths in science (McConnell, 1997), and poor understanding of technology and of the role played by industry in contributing to the national well-being (ASTEC, 1991b). Career influences include the career relevance of a subject (Cameron, 1989; Crawley & Black, 1992; Dekkers et al., 1986; Pollack, 1981/1982; Wood & de

Laeter, 1986), career advice and infrastructure (ASTEC, 1991a; Rennie & Dunne, 1994), lack of firm career structure (Australian Academy of Science, 1991; Lowe, 1996b; Lowe, 1997), and keeping options open (Sleet & Stern, 1980).

Woods (1979) found that Year 9 girls tended to be more influenced than boys by affective factors, with boys having a stronger career orientation and being less swayed by affective considerations. At Year 11, both Sleet and Stern (1980) and Cameron (1989) found that for students who had chosen to study chemistry or physics, career factors were the most important for both girls and boys. However, for students taking biology, interest and enjoyment was the most common reason for choosing the subject.

It seems that attitudes concerning the future study of science subjects or the pursuit of science-oriented careers are often formed during students' early years of secondary school (Anderman & Maehr, 1994; Department of Industry, Science and Tourism, 1996) and that at this time these attitudes are more positive in boys than in girls (Erb, 1981; Rosier & Banks, 1990).

2.4 Perceptions About Scientists

A number of writers have suggested that students' negative stereotypic image of scientists could contribute to their avoidance of science courses or career choices (Ahlgren & Walberg, 1973; Gardner [cited in Mason, Kahle, & Gardner, 1991]; Harvey, 1995; Hudson, 1967; Kahle, 1989; Mason [cited in Mason, Kahle, & Gardner, 1991]; McNarry & O'Farrell, 1971; Mead & Metraux, 1957; Mitias, 1970; Purbrick, 1997; Rosenthal, 1993). Many writers have also suggested that students, not just in Australia but in other countries as well, generally hold a stereotypical image of scientists and this image appears to have three parts (Burnet, 1993; Clifton, 1993; Schacht cited in Cribb, 1993; Cribb, 1995; Fort & Varney, 1989; Free [cited in Cribb, 1991a]; Free, 1993; Harvey, 1995; Head, 1985; Hudson, 1967; Kahle, 1989; Krystyn, 1986; Mocellin, 1994; Williams, 1993; Woolcott Research Pty Limited, 1995). Of the authors reporting directly the results of research including Australian students, Woolcott Research Pty Limited based their conclusions on data from group discussions, telephone surveys, and interviews while the conclusions of Harvey and Kahle were based on the Draw-A-Scientist Test (DAST).

One part of this stereotypical image comprises factors that students consider to be positive, and includes descriptors such as intelligent, high level of expertise, hard-working, committed, patient, careful, and working for the good of humanity. Another part comprises negative factors such as physically unattractive, obsessive, male-only, cold, uncool, different, loser, nerd, dull, alone, neglectful of wife and children, no friends, never home, geek, pursuing unrewarding career, menacing, secretive, dishonest, dork, social outcast, isolationist, lonely, mad, wild hair, doesn't know what is going on in the outside world, no other interests, neglects his body for his mind, doesn't care about appearance or meals, eccentric, sinister, and antisocial or poorly adjusted. A third part, comprising factors which might be considered neutral, includes white coat, spectacles, and facial hair. Also, there is evidence for a differential degree of stereotyping across socio-economic groups, with the popular media possibly having a greater stereotyping effect on children of higher socio-economic background (Chambers [cited in Schibeci & Sorensen, 1983]; Schibeci & Sorensen, 1983).

Further, it has been suggested that as primary school children, again not just in Australia but also in other countries, get older, they appear to stereotype scientists more and more (Bowtell, 1996; Chambers, 1983; Harvey, 1995; Schibeci & Sorenson, 1983). While Newton and Newton (1992) found that a stereotypical image may be acquired as early as 6 years of age, Purbrick (1997) concluded that negative stereotypic influences were consolidated prior to Grade 6. However, the conclusions of these studies were based on DAST data, and since features of the DAST must be questioned, these conclusions should be viewed sceptically. First, the validity of DAST data appears doubtful. Ó Maoldomhnaigh and Hunt (1988), McNay (cited in Jackson, 1992), Som, Hill, and Wheeler (1989), Jackson (1992), and Dawson (1997) have all considered that students' perceptions of scientists could be far broader than such a simple drawing could reveal, with Bowtell (1996) finding that Year 5 and 6 children "said that scientists are normal but still drew the stereotypical standard image" (p. 12). Kahle (1989) addressed the question of validity by reporting a then-to-be-published study (Tobin, Kahle, & Fraser, 1990) in which she said "when an Australian researcher interviewed Year 10 students after they drew scientists, in most cases their verbal images matched their visual ones" (p. 4). However, the author could not find any reference to such a matching process in the published study. The question to be asked is: How significant is *most* in Kahle's quotation? Is *most* sufficiently high to validate the DAST and hence its use in determining trends? A decision about the validity of the DAST appears better left until after further (and especially large-population) research.

Second, although Sumrall (1995) reported difficulties with the inaccurate categorisation of DAST drawings by researchers, Ó Maoldomhnaigh and Hunt (1988) and Mason, Kahle, and Gardner (1991) did establish the reliability of scoring the DAST from the point of view of the level of agreement between different people coding the drawings. But this is only one aspect of the reliability of the test. Could a student not possess more than one definition of a scientist, for example, and therefore draw different images at different times without their perceptions having been changed? How significant are such considerations? Once again, further research appears warranted.

2.5 Science in Society

Mention was made in chapter 1 of the poor perception among young Australians about the role of science in society. In British Columbia, Ebenezer and Zoller (1993) reported a decline in the attitudes of Year 10 students in 1989 compared with 1986 regarding the value of science to society and remarked that this result may be considered somewhat surprising given the expected positive impact of the STS-oriented approach to science teaching in British Columbia during this period. However, cause for optimism in the Australian context was also documented in chapter 1 in the form of recent reports showing an increased acknowledgment by young Australians of the importance of science and technology to Australia.

Khalili (1984/1985) found that students choosing to continue their study of science rated the social implications of science higher than students who were not inclined to continue. Haladyna, Olsen, and Shaughnessy (1982) reported a strong positive correlation between students' views of the importance of science and their attitudes toward science, described in terms of their interest and enjoyment in being involved in science and their motivation to continue science. However, *importance of science* is not defined, with one sample item only ("Science is a worthwhile and necessary subject") given and the others not readily available. This variable may therefore not necessarily reflect students' views of the importance of science in society.

2.6 *Effects of Activities on Student Attitudes*

There is anecdotal evidence for the positive effects on students' attitudes of participation in enrichment and extracurricular science activities. Broniec (1986) reported how after-school-hours tutorials conducted by volunteer research chemists at their workplace for high school students experiencing difficulty understanding chemistry had a positive effect on students' interest and enjoyment in the subject, Rapp (1992) concluded that an extracurricular program for minority and at-risk Grade 9 students increased students' interest in science, and Lowe (1994) communicated an increase in the number of high calibre students applying to study science or engineering at university since university summer schools were introduced. Stazinski (1988) suggested biological competitions can increase students' interest in biology, Brown (1992) observed that a project involving the design and construction of two space experiments drew many girls to science, and Devlin and Williams (1992) related the story of a student who, as a result of being guided by an interested teacher and spending time in the school laboratory as a lab assistant, was started on the road to a future in chemistry and biochemistry. Cribb (1991b) reported that the Shell-Questacon travelling science show increased the interest and enthusiasm of children in science, Boon and Roth (1992) said that a large-scale physics and chemistry show for middle-school students can increase science class enrolments, and Beruldsen and Mau (1991) suggested a school-based Science Expo can stimulate the interest of attending primary school students. Elms (1993) tells of her decision, during a Careers Week tour, to want to be a scientist, "Receiving science" (1993) reported that a 3-day conference influenced some girls to continue to participate in science, and Hickman (1976/1975) said field trips increased students' interest in class discussions and daily work.

In contrast with these anecdotes, the following reports the results of more structured research. Appendix 2.A contains a more exhaustive list of the studies reviewed, including those studies which were omitted from the following synthesis for reasons which are also given in the appendix (e.g. attitudes [the dependent variable] not defined, different from those in this research, or not representing a single construct, methodology not detailed, and conclusion not justified in view of the methodology employed). Given the close association between interest and enjoyment in being involved in science activities and motivation to continue to participate in science established in section 2.3, the effects of activities on these dependent variables are discussed jointly.

Interest, Enjoyment, and Motivation

Science centres/museums. In order to determine the effect of a planetarium environment on the subject choice of 112 astronomy and 146 physical science college students (the latter serving as a comparison group), Reed (1975) administered an eight-question survey (seven questions requiring a checked response and one a written response) at the beginning of their courses. At that time, practically all the students knew what a planetarium was, 80% of both groups had previously been to a planetarium, and there was a high degree of awareness among both groups that the college astronomy course would be taught in the college planetarium. The responses indicated that the use of a planetarium in teaching the college astronomy course, by increasing students' interest and motivation, was a very strong influence in students scheduling the astronomy course.

Sneider, Eason, and Friedman (1979) used a posttest-only design in studying the effect of visiting the Star Games exhibit at the Lawrence Hall of Science on 138 high school students assigned randomly to an experimental or control group, the latter visiting other exhibits. The posttest instrument took the form of a Raffle Choice, where students were asked to choose to enter a raffle for one of four books; two related to astronomy and two concerned with non-astronomy topics. The results showed that the exhibit had no effect on the interest of students in reading more about telescopes and astronomy. However, this finding conflicts with the significant preference for visual materials related to astronomy reported in a pilot study involving 117 students in which posters rather than books were used in the posttest instrument. While the authors concluded that these conflicting findings warranted further investigation, this study demonstrates how different ways of supposedly determining students' interest in learning more about telescopes and astronomy can produce different results.

Gottfried (1980) reported that a visit to Biolab, a biology discovery room at the Lawrence Hall of Science, was "accompanied by important motivational . . . benefits to children" (p. 174). This conclusion was based upon different methods of data collection, involving 400 children in multiple visiting groups, employed in such a way that any conclusion could be checked from at least two sources. These methods included a questionnaire developed and administered 1 week before the visit and, upon arrival of a group, the random choice of a "focal individual" who was closely observed during the 1-hour visit and whose questions were recorded.

Borun, Flexer, Casey, and Baum (1983), in a study involving 416 Grade 5 and 6 students visiting an exhibit comprising five participatory devices (involving levers, inclined planes, and pulleys) at The Franklin Institute Science Museum and 535 Grade 6 and 7 students visiting the temporary *Planets and Moons* exhibit at the Museum of Science in Boston, concluded that the majority of visiting students were motivated to learn more about the science content demonstrated or displayed. However, this conclusion was based upon one posttest survey item only, "How interested would you be in learning more about . . .?," requiring a choice of one from four given alternatives.

In a study of 816 Grades 5 to 7 students who participated in a tour of a natural history exhibit *Living Land - Living Sea* at British Columbia Provincial Museum, Stronck (1983) found that neither the more-structured nor the less-structured tour made any significant difference to the students' desire to study about animals living in the forest and the sea. However, this conclusion was again based upon results from one Likert-type item (with five alternatives) only used as part of a pretest/posttest attitude questionnaire comprising 20 items (the items are not given). Further, the pre-tour attitudes of both groups were very high (4.22 and 4.30 out of 5). With little scope for improvement, this "ceiling effect" may have impeded the ready detection of any increases.

Institutes. Mares, Levine, Russell, and Hamilton (1985) used the question "How did the Summer Scholars Program impact on you as it relates to your senior years in high school?" on a questionnaire to assess the impact of a 4-week program aimed at motivating minority and low-income high school students toward health sciences careers. Responses from the 18 seniors of the 24 selected volunteers indicated that the program appeared to have a strong impact on students with regard to career confirmation or, at least, narrowing of choice.

Saeger and Valesky (1984) used a questionnaire, of which the format and other details are not given, in an attempt to determine the influence of an 8-week summer Health Careers Opportunity Program (HCOP) on 40 minority students. The responses of the participants were compared with those of a control group comprising apparently comparable students who had applied to do the course but were either not selected (no details about the selection criteria are given) or who declined to participate and it was found that students who participated in the program were more likely to be enrolled in science-related coursework. However, contributing this result to the impact of the HCOP program does not appear justified. The only check on comparability between the action and control groups was academic aptitude, so the sample of students chosen could easily have been biased towards those students likely to give the result reported.

A pretest-posttest experimental design involving both qualitative and quantitative survey data collection was used by Barber, Beard, Moore, and Van Voorhees (1986) to study the effect of a mentoring academy on 30 Year 7 and 8 girls selected on the basis of high achievement (on school test scores or school honour roll) and low career aspiration (Career Attitude Survey). Fifteen teachers, trained in the mentoring process, provided opportunities for the girls to attend workshops and lectures, participate in tours, and to receive information about careers which use mathematics, science, and technology. Girls meeting the above-mentioned criteria and not selected acted as a control group (although no further details about the selection procedure are given). The results support the premise that teachers can positively influence girls' career aspirations.

Hofstein, Maoz, and Rishpon (1990) used a 50 Likert-type item attitude questionnaire, covering a range of constructs, at the end of the school year to conclude that participation in extracurricular science activities positively influenced students' interest and enjoyment in being involved in science. The activities were either a weekly (over about 6 months) or 2 - 4 week summer program and conducted at universities. However, by simply comparing the results for Year 8 and 11 students who voluntarily enrolled for the programs with those for the students who did not enrol, these researchers simply showed that students who enrolled had greater interest in science than those who didn't, which is hardly surprising. Their conclusion about the effect of participation in the activities appears unjustified.

The influence of a 3-week Science Academy Summer Institute on 160 middle school students (students going into Grades 7, 8, and 9) was studied by Williams-Robertson (1990). The Institute involved creative courses, hands-on techniques, and frequent field trips. Its effect was evaluated using a survey composed of both open-ended and forced-choice questions which showed that more than half of the students who participated experienced an increase in interest in science.

Practical work. Olson (1985) used one question, requiring a *yes, somewhat,* or *no* response, in a survey of 213 finalists (80% response rate) in the North Dakota Science and Engineering Fair from 1951 - 1985 to determine if the fair had any influence on their career choice. Most (73.5%) believed that the fair had definitely, or somewhat, influenced their career choice, and 51% of the sample had subsequently selected science professions. The ratio of voluntary fair participants to those who had been required to compete was about 3:1.

A 58-item attitude questionnaire was used by Silverman (1985/1986) to monitor the effect of a 6-week science fair project experience on 200 Grades 7 - 9 students in a school. Two hundred matched students in a nearby school served as a control. Individual and group participants who completed a project were found to have increased interest in science. Importantly, however, the students in the treatment school who did not complete a project or who did not do a project don't appear to have been included in the data used to reach the above conclusion, so the conclusion appears limited to students who completed a project as opposed to the student population in the treatment school in general.

Gennaro, Hereid, and Ostlund (1986) followed up on the effects of five separate short out-of-school science courses for which 158 Grades 6 - 8 students and their parents (mostly in pairs) registered voluntarily. Data were collected 2 - 3 years after the courses were conducted using mainly telephone and mail questionnaires, with face-to-face open-ended probe interviews with six student-parent pairs used to generate the questions. This methodological triangulation was supported by investigator and data triangulation. Over one-half of the 50 parents who responded to the survey questionnaire reported that their child's interest in science increased as a result of participation in the courses, and results for parents and students interviewed by telephone supported this finding. The Communications Technology and Nighttime Astronomy courses seemed to have the greatest influence.

Krystyn (1986) used interviews with teachers and students to conclude that the Science Talent Search, an annual event conducted by the Science Teachers Association of Victoria for students in Years P - 12, was successful "at getting people interested in and involved in science activities" (p. 47). Diamond, St. John, Cleary, and Librero (1987) studied teenage explainers who had acted as volunteer explainers at the Exploratorium in San Francisco. Thirty-two were given lengthy interviews and a further 116 were surveyed using questions developed during the interviews. The experience was found to increase the curiosity and interest of explainers in learning science, with those interested in science more likely to be influenced to take more science courses later in school and 24% strongly influenced to go to college after high school.

Tutor program. In Project SEARCH (Science Education and Research for Children), university science students brought activity-based learning, plus materials and content expertise, to local classrooms and after-school programs in elementary schools (Bruce, Bruce, Conrad, & Huang, 1997). Using observations, surveys, and interviews, the researchers concluded that participation in the project had reinforced in many of the 48 5- to 12-year-old children that they could be scientists too.

Finally, Woolnough (1994) analysed questionnaire data from 1180 18-year-old students in schools in England to conclude that participation in extracurricular science activities such as speakers, visits, clubs, work experience, and competitions played a major role in motivating students towards higher education in one of the physical sciences or engineering. This result is consistent with his finding (Woolnough, 1993), based on questionnaire data from teachers in a 10-percent sample of English schools, that the existence of such activities in schools correlated highly and positively with the success of the school in sending students on to higher education in these areas.

Scientists

Institute. Finson, Beaver, and Cramond (1995) studied the effects, on 24 Grade 8 students, of a career-oriented interdisciplinary science program designed purposely to expose students to alternative images of scientists; females, various cultural groups, and work in natural settings. The program included lectures, laboratory work, discussions, and field experiences conducted by university staff and research projects conducted by their teachers. Twenty-three students experiencing a normal classroom science curriculum served as a control group, with a Draw-A-Scientist Test (together with a checklist developed for use with it) used as a pretest and posttest and again as a delayed posttest for the treatment group 5 months after the posttest. The delayed posttesting "showed far fewer stereotypical images and illustrated a more realistic and broader image of the variety of persons involved in science" (p. 200).

Role model/tutor programs. To assess the effect of a 2-month treatment on 286 female and male students in Grades 5 - 8 in eight American locations and representing a variety of racial and socioeconomic backgrounds, Smith and Erb (1986) used a pretest-posttest (both involving two attitude scales) control group experiment. The treatment comprised exposing students to at least three women science career models, and reading about at least six young women who used science in their work, while control students received additional instruction on the science topics being studied. It was found that treatment students had significantly more positive attitudes toward scientists and towards women in science than the control students.

Flick (1990) found that a Scientist in Residence Program, involving university scientists visiting Grade 5 classrooms, had a positive influence on children's perception of scientists. Two Grade 5 classes each hosted a scientist for 1 hour each week for 3 consecutive weeks, then repeated this set of visits with another scientist, and participated in a field trip to their labs. One class had two female scientists and the other had a male and a female. Data were collected using a Draw-A-Scientist pretest and posttest type experimental design together with a written posttest response from students about what they had remembered from the visit and if their perception of science or scientists had changed. Grade 6 students in another school formed a control group.

In conclusion, the literature contains evidence that science enrichment and extracurricular activities such as visits to museums, science centres, and institutes, practical work, and tutor programs can have positive effects on students' interest and enjoyment in being involved in science activities, their motivation to continue to participate in science, and their perceptions about scientists.

2.7 The Structure of Enrichment and Extracurricular Activities

Introduction

Suggestions for the effective implementation of enrichment and extracurricular science learning experiences can be found in a wide range of resources including books (Jennings, 1986) and documents (National Aquarium in Baltimore, 1983), support materials provided by science centres (Quinn, 1990), museums (Queensland Museum Education, n.d.) and amusement parks (Dreamworld, n.d.), and journal articles, especially those aimed at the classroom teacher (Baldock, 1973; Balson, 1973; Dickey, 1980/1981; Fischer, 1984; Kuhn, 1990/1991; Percey, 1987; Pratt, 1973). Swartz (1991), for example, in giving his opinion of the desirable features of a science museum visit, identifies the need for specific goals, non-trivial questions, the examination of only a small number of exhibits and a follow-up test in the classroom. The authority base for contributions like those above varies widely and includes the personal experience and opinion of authors and brief oral and written feedback from teachers and students.

Appropriate methods for implementing such science activities, which often take place outside the classroom, traditionally appear to have received little consideration during teacher training courses (Eastwell,1994; Hickman, 1976/1975; Keown, 1986; Shepley, 1974). If the outcomes for students from these types of learning experience may depend upon their structure, a review of the research literature is appropriate to identify those strategies found to be the most effective in achieving the desired aims of the activity.

Table 2.1 summarises the research literature. Each contribution in the table is dual classified; first under a general (sometimes overlapping) heading which represents the particular strategy researched in the study and second, as to whether the effect of the implementation of the relevant strategy was researched from the point of view of cognitive objectives, affective objectives, or both. The second

Table 2.1
Research Contributions to the Effectiveness of Various Strategies in Implementing Science Activities

Strategy	Focus domain
Orientation and previsit strategies	Cognitive Delaney, 1967 (atomic laboratory, Gr. 7) Gennaro, 1981 (science museum film, Gr. 8) Stankiewicz, 1984 (science museum, Gr. 7, 8) Giles & Bell, 1982 (planetarium classroom, 15-16 yrs) Falk & Balling (in Disinger, 1984) (zoo, elementary) Cognitive and affective Braverman and Yates, 1989 (zoo, adults) Fortner & Lahm, 1990 (estuarine sanctuary, Gr. 4, 5)
Active/passive participation	Cognitive Shettel, 1973 (in Fortner and Lahm, 1990) (museum) Screven, 1974 (in Koran & Baker, 1979) (museum/learning centre) Thier & Linn, 1975 (review) Boisvert, 1992/1993 (science museum) Mackenzie & White, 1981 (field trip, Gr. 8,9) Cognitive and affective Mallon & Bruce, 1982 (planetarium, 8-10 yrs) Not specified/relevant Price & Hein, 1991 (range of programs, mainly primary)
Novelty-reducing strategies	Cognitive Falk, Martin, & Balling, 1978; Balling & Falk, 1980; Falk & Balling, 1980; Martin, Falk, & Balling, 1981; Falk & Balling, 1982; Falk, 1983 (various outdoor settings, 8-13 yrs) Ridky, 1973/1974 (planetarium, jun. high & college) Stronck, 1983 (museum, Gr. 5-7) Kubota & Olstad, 1991 (science centre, Gr. 6) Cognitive and affective Orion & Hofstein, 1994 (geologic field trip, Gr. 9-11)
Structured/ less structured instruction	Cognitive Cañizales de Andrade, 1989/1990 (a science exhibit, Gr. 2,3) Lucas & McManus, 1986 (discovery room, pupils) Affective Finson & Enochs, 1987 (science-technology museum, Gr. 6-8) Cognitive and affective Stronck, 1983 (museum, Gr. 5-7) Not specified/relevant Birney, 1988 (museum & zoo, Gr. 6) Price & Hein, 1991 (range of programs, mainly primary)

Table 2.1 (con't)

Strategy	Focus of domain
Group interaction	Cognitive Taylor, 1986/1987 (aquarium, family groups) Diamond, 1986 (museum types, family groups)
Worksheets	Cognitive Lehman & Lehman, 1984 (museum, undergraduates) Screven, 1975 (gallery, ≥ 14 yrs) De Waard et al., 1974 (museum, ≥ 13 yrs) Korn, 1988 (gardens, ≥ 16 yrs) McManus, 1985 (museum, up to 15 yrs) Not specified/relevant Price & Hein, 1991 (range of programs, mainly primary)
Time spent	Not specified/relevant Falk, Koran, Dierking, & Dreblow, 1985 (museum, > 16 yrs) Taylor, 1986/1987 (aquarium, family groups) Shettle (*sic*, in Kimche, 1978)(no details given) Borun, 1977 (museum, all ages) Price & Hein, 1991 (range of programs, mainly primary)
Variety in activity type	Cognitive Koran & Baker (in Price & Hein, 1991) (field trips) Linn, Chen, & Thier, 1977 (enrichment centre, 11-12 yrs) Not specified/relevant Price & Hein, 1991 (range of programs, mainly primary)
Observation before concepts, or the reverse?	Cognitive Price & Hein, 1991 (range of programs, mainly primary)
Rewards	Cognitive Slavin, 1984 (classrooms, Gr. 3-9)

categorisation is not appropriate for those studies in which the desired outcomes are not clearly specified and is not relevant in some other cases.

Although the research reported in this thesis focuses on the affective outcomes of science activities, both cognitive and affective outcomes have been included in this literature review because they appear to be closely related and can reinforce one another (Rennie, 1994; Wellington, 1990). Structures which enhance cognitive outcomes by focussing student attention, for example, could perhaps be envisaged to have a similar positive effect on affective outcomes. McManus (cited in Rennie, 1994) put it more strongly, arguing that the artificial distinction between affect and cognition is best forgotten. Also, perusal of Table 2.1 shows that nearly all the reported studies have been confined to visits to venues such as museums, science centres, planetariums, and zoos and have focussed on cognitive outcomes. These research findings are now discussed.

Orientation/Previsit Strategies

In a review of early literature, Hartley and Davies (1976) concluded that "in the majority of studies, preinstructional strategies have not always produced clear-cut advantages for the learner, nor have pretest effects been discernible. Behavioural objectives, overviews, and advance organisers, on the other hand, generally seem to have an effect or advantage. In no case, however, is this advantage clear-cut" (p. 256). Evidence for the positive effects of the use of behavioural objectives and pretests on learning in the museum context is given in the literature review of Koran and Baker (1979), with these authors also claiming the positive effects of these strategies in the field trip context, although no direct evidence is given in support. The desirability of providing behavioural objectives to students is also supported by Balson (1973), Wilson and Koran (1976), Follette (cited in Rennie, McClafferty, & Johnston, 1993), and Hoke (1991), with Rennie, McClafferty, and Johnston further stressing that these objectives should include the nature and requirements of post-visit activities.

Delaney (1967) studied the effect, on factual gain, of a 40-minute introduction to a visit by seventh-grade science and social studies students to Brookhaven National Laboratory (an atomic laboratory) during visitors week. The orientation program on the day prior to the visit included a lecture and the use of slides, audio tape, brochures, and an orientation map. An experimental/control group methodology was employed, with each of these groups containing three ability subgroups (below average, average, and above average) determined and matched on the basis of students' scores on the California Test of Mental Maturity and sundry reading scores. He concluded, on the basis of a multiple-choice posttest measuring knowledge, that while this previsit program did significantly benefit students of average and less than average academic ability, students of superior academic ability did not benefit significantly from the orientation. However, the internal validity of these results could be questioned. No attempt was made to match the control and experimental groups for other factors which may have influenced the results, such as a prior visit to the venue or prior knowledge. Delaney could have strengthened his methodology by, for example, omitting from both the control and experimental groups any students who had made a previous visit to the laboratory and by using a pretest, analogous to the posttest, to match the groups for prior knowledge.

Gennaro (1981) used an identical pretest and posttest in his experimental/control group study of the effect of 4 days of previsit instruction on the cognitive performance of Year 8 students following a visit to the Omnitheatre at the Science Museum of Minnesota to view *Genesis*, a film dealing with the big bang theory and the theory of plate tectonics. This previsit instruction included the use of study sheets, demonstrations, and hands-on experiences designed to focus on the concepts developed in the film. The test included factual and comprehension questions as well as questions requiring analysis and synthesis. The results of the study demonstrated the value of the use of the previsit strategy. Further, in contrast to the findings of Delaney (1967), Gennaro concluded that the previsit instruction used in this study was of benefit to students of all ability levels. Since some of this previsit instructional material had the characteristics of advance organisers, this result is in accord with not only the general ability of advance organisers to facilitate learning (Novak, 1976), but also the review of Barnes and Clawson (1975) which suggested that advance organisers have similar effects on learning for students of varying ability. Stankiewicz (1984) subsequently found a similarly beneficial effect of an advance organiser on the ability of seventh- and eighth-grade science students to recall and apply facts after a visit to a science museum.

The effects of using advance organisers and clustering of concepts in a planetarium classroom was studied by Giles and Bell (1982). The subjects, 15- to 16-year-old students, received one of four treatments. The first treatment group, the control group, was given the traditional (taped) lecture presentation. The second treatment involved the lecture plus the clustering of concepts. The third treatment group had the lecture with advance organisers (in the form of slides illustrating basic geometric shapes) provided by the planetarium teacher. The final treatment group also had the lecture but with clustering of concepts and the advance organisers. All groups were pretested and posttested (1 week after treatment) with the same multiple-choice instrument. It was found that advance organisers and clustering applied singly improved the posttest results when compared with results of the control group students, although the advance organisers did not have the same effect on students of all ability. The most effective treatment, however, was the combination of advance organisers with clustering. Giles and Bell suggested that future research could consider those properties of advance organisers which have most effect on higher and lower ability groups.

Disinger (1984) cites the work of Falk and Balling as stressing the need for orientation prior to a field trip. In their study of learning associated with a single-visit, structured tour by elementary students of a specific area of a zoological park,

> the most effective pre-trip orientation . . . was that conducted by the students' classroom teacher, trained by a targeted workshop, as opposed to orientation by a resource person from the zoo or by a classroom teacher supported by mailed printed materials only. (p. 3)

An experimental/control group methodology with pretest and posttest was used by Braverman and Yates (1989) to study the effects of two orientation programs on both the cognition and affect of adult professional youth workers (majority female) visiting the San Diego Zoo during one of their conferences. In this study, however, the pretest and posttest contained different knowledge questions but the same attitude scale. The two orientation programs contained parallel content focussing on background and behind-the-scenes information about this zoo (and others) and the work of zoos in education and species preservation. While one orientation program used a lecture-with-slides approach, the other required participants to read a given packet of orientation materials.

While both orientation programs were effective in producing posttest knowledge scores significantly higher than those for the control group, two results in the cognitive domain are interesting. Firstly, the lecture group scored slightly higher than the reading materials group on those posttest questions involving material contained in the orientation programs. Most notably, however, the reading materials group scored significantly higher than either other group on those posttest questions which could only be answered during the zoo visit. No difference in performance between the lecture and control groups was found on these questions.

In the affective domain, the focus of this study was on participant attitude to zoos and attitude towards the potential use of zoos in the work of youth workers. Neither orientation program was found to have any effect on such attitudes, although the authors note that a *ceiling effect* may have been operating; that is, the initial attitudes of the participants were so high that there was insignificant room for an increase.

A pretest/posttest design with experimental and control groups was used by Fortner and Lahm (1990) to study the cognitive and affective effects, on Year 4 and Year 5 students, of a previsit programme and visit to the Old Woman Creek National Estuarine Research Reserve. The control group did not participate in either the previsit program or the visit. The previsit program comprised a 0.5-hour slide presentation (an overview of the estuary) given at the students' schools by estuary personnel followed by studies in the classroom of Old Woman Creek using information packets supplied by Creek staff (in which teachers had free choice of presentation methodology). The visit occurred 3 weeks after the slide presentation.

The pretest and posttest contained different cognitive items and a third version of these tests (the previsit test) was also administered to some students after the in-school instruction but before the visit. Most cognitive items on each test were of a factual nature, although some analysis and synthesis questions were also included. Each test contained the same affective items pertaining to topics such as preservation and the use of areas such as Old Woman Creek.

Fortner and Lahm (1990) found that there was a significant gain in knowledge from pretest to posttest for both Years 4 and 5 students. Interestingly, the greatest knowledge gain occurred between the pretest and previsit test (a result of the in-school program), even though significant gains were documented between the previsit test and posttest. However, in the absence of a group of students who were not exposed to the previsit programme but did participate in the estuary visit, valid conclusions cannot be drawn about the relative contributions of the previsit programme and estuary visit to the cognitive gain of students. Students could exhibit cognitive gain comparable with that of the experimental students as a result of the visit alone. It appears that the results and discussion pertaining to attitude change are contradictory and thus inconclusive.

In accord with the conclusions of these studies, Price and Hein (1991) cite Koran and Baker, Melton, Feldman, and Mason, and Mackenzie in support of the value of previsit strategies in achieving cognitive outcomes from non-school science activities when they state that "most students who have been prepared for field trips by their teachers concentrate better and learn more from the experience" (p. 514). The benefits of such strategies are also supported by the experience of McGlathery and Hartmann (1973) who add the use of kits, resource persons, and preparatory (possibly short and local) fieldtrips to the list.

Price and Hein (1991) found that involvement by teachers in all phases of a programme (including pre-programme orientation) positively affected "both teacher and student attitudes, discipline, interest, willingness to help and carry-over to school. In one programme the Program Evaluation and Research Group (PERG) evaluated, student curiosity was reported to be directly proportional to teacher interest" (p. 514). Such involvement is in accord with the need for teacher preparation which might, as advocated by Voris, Sedzielarz, and Blackburn (cited in Price & Hein, 1991), typically involve collaboration with staff at the centre being visited. Pratt (1973) and Hoke (1991) advocate a preliminary visit to a site by the teacher.

Active/Passive Participation

In the museum and learning-centre setting, Screven (cited in Koran & Baker, 1979) found that the addition of interactive devices to exhibits significantly enhanced learning by increasing motivation, resulting in more time and effort being devoted to the mastery of content. While acknowledging that non-interactional instructional procedures may offer science facts in a more time-efficient manner, Thier and Linn (1975) use both informal and research evidence to conclude that science centre programs need to have a significant interactive aspect in order to promote an understanding of the nature and process of science.

The relative effectiveness of two different approaches to the use of a planetarium was studied by Mallon and Bruce (1982). The more commonly used Star Show presentation, comprising a recorded lecture with planetarium projection plus music, was compared with the Participatory Oriented Planetarium (P.O.P.) program comprising a discovery/inquiry/activity based approach involving extensive verbal interaction between audience and instructor plus the use of slides as well as the planetarium projector. The same paper and pencil pretest and posttest, involving both content questions and a science opinionnaire, was used in this large scale study to determine the effect of a planetarium visit on 8- to 10-year-old students; although some students were not given the pretest. The impression given is that the content questions were designed to test student recall, although this is not clear; the term "students' understanding" (p. 56) is also used in a description of the aim of the test. The researchers concluded that the P.O.P. program was clearly the more effective strategy for teaching about constellations. The results in the affective domain were not so clear-cut. In general, both approaches saw students who entered the study with positive attitudes about astronomy and the planetarium leave the study with either the same or more positive attitudes. However, there was some inconsistency in the results from the two approaches, allowing only the conclusion that the P.O.P. approach may be better at improving students' attitudes.

Price and Hein (1991) reviewed the work of PERG at Lesley College in evaluating a wide variety of informal, non-school science programs for mainly primary school students over some 15 years. Together with Brooks and Vernon (1956), Birney and Meier (cited in Price & Hein, 1991) and Koran, Koran, and Longino (1986) they provide further support for the superior effectiveness of interactive learning experiences over lectures or demonstrations.

In a study involving visitors to a science museum discovery space, Boisvert (1992/1993) found that although all subjects showed some improvement in conception (the type of conception is not described, although Piagetian-style interviews were used to measure it) after interaction with one of two exhibits, higher frequencies of changes in conception were seen in subjects who used the less interactive exhibit. However, these results should be interpreted with caution in view of the small sample size (20 subjects) involved in this part of the study.

Mackenzie and White (1981) studied the effects of fieldwork (compared with classwork alone) on the ability of 141 Grade 8 and 9 students to retain geographical facts and skills and compared the outcomes in this area for two differently structured fieldtrips. While students who participated in either fieldtrip outperformed students who did not participate in a fieldtrip, those students who participated in the active fieldtrip--requiring knowledge and idea processing--outperformed the passive fieldtrip students, not only at the conclusion of instruction but also 12 weeks later.

Novelty-Reducing Strategies

Falk, Martin, and Balling (1978) found that the novelty (to the learner) of a new environment can interfere with task learning. Their study, also reported in Balling and Falk (1980) and Falk (1983), involved 10- to 13-year-old students participating in an educational activity in a wooded setting at the Smithsonian Institution's Chesapeake Bay Center for Environmental Studies (CBCES). The students were placed in two groups, *Familiar* and *Unfamiliar*, reflecting their previous contact or otherwise, respectively, with both CBCES and a wooded setting (although not the CBCES woods). The groups were matched for a variety of variables, including academic aptitude determined on the basis of IQ scores. An identical pretest and posttest, containing questions testing both familiarity with wooded and old field areas and knowledge of concepts presented in the structured learning activity, was used. Whereas both groups showed similar increases in scores on questions pertaining to the setting, students in the *Familiar* group were able to learn about wooded settings and learn ecological concepts simultaneously while *Unfamiliar* group scores on questions dealing with the latter actually showed a slight decline from pretest to posttest.

Three ensuing studies were reported, with some overlap, by Balling and Falk (1980), Falk and Balling (1980), Martin, Falk, and Balling (1981), Falk and Balling (1982), and Falk (1983). These studies addressed the effect of the novelty of various outdoor settings on student learning, used pretest-posttest experimental designs and focussed on subjects in the 8 to 13 years age group. Although students who were unfamiliar with a setting did learn science, they did not learn to the same extent as students more familiar with the environment. In addition, one study also found that too little novelty can also be counter-productive to task learning. It was concluded that repeat visits to a site often produce the best cognitive outcomes for students of all ages, but particularly for early elementary school-aged children. Falk (1983) made further brief mention of the results of two other studies which support the inhibiting effect on learning of a novel environment. In conjunction with one of these, a large-scale study, he concluded that "lest there be any doubts about the universality of the phenomenon, these children too, exhibited a novel field trip phenomenon" (p. 141).

In the case of a single-visit learning experience, the advice of Falk, Martin, and Balling (1978) appears relevant. Rather than treating the novel field-trip phenomenon as a "negative behavior to be overcome before 'real' learning can occur," it should be considered "as a dialogue between the child and his environment--something to understand and capitalize upon" (p. 133). Provision for an introductory exploratory activity upon arrival aimed at familiarising students with the setting could therefore be a useful strategy where circumstances allowed. Koran, Longino, and Shafer (1983) subsequently concluded that, in accord with the review by Falk (1983), "it would appear advisable to take steps to reduce the novelty of the environment by providing advance instruction or a previsit to familiarise students with the environment" (p. 329).

Orion and Hofstein (1994) broadened the concept of novelty of a field setting by suggesting that the *novelty space* experienced by students consisted of at least three factors: cognitive (concepts and skills students are asked to deal with during a field trip), geographic (acquaintance with the area), and psychological (previous experience in field trips as social-adventurous events rather than learning activities). They used an achievement test and three attitude questionnaires to conclude that Year 11 students whose novelty space had been reduced in all three ways before a 1-day geologic field trip gained significantly higher achievement and also higher attitude levels on some scales (two of the five *Attitudes Towards Field Trips in General* scales, two of the four *Attitudes Toward a Specific Field Trip the Students had Experienced* scales, but none of the three *Attitudes Toward Geology* scales) than students whose novelty space had not been so reduced.

While the studies referred to thus far have focussed on field trips, Ridky (1973/1974) found that a novelty-reducing orientation session describing the equipment used could control the *mystique effect* which inhibited the content learning of junior high and college students visiting a planetarium and Stronck (1983) similarly found an effect, of what were novel circumstances, on task learning in the museum setting. The details of Stronck's study are given later. Kubota and Olstad (1991) further reinforce the presence of a novelty effect in a study of Grade 6 students visiting the Pacific Science Center's Science Playground containing a collection of interactive, hands-on, physics-oriented exhibits. They used a posttest-only placebo group design, with students assigned randomly to a treatment and placebo group, and differentiated between specific exploration (associated with a particular, novel stimulus such as an exhibit) and diversive exploration (associated with the novelty of the environment in a broader sense and the type of exploratory behaviour referred to in the studies outlined above). These researchers found that the novelty-reducing preparation, comprising a vicarious exposure to the exhibits through a slide/tape program, resulted in increased specific exploration and greater cognitive learning for boys but no gain in either area for girls. By reducing the novelty of the site, the preparation program apparently minimized diversive exploration and thus led to improved on-task exploration and cognitive scores for boys. The authors raise the issue of sex-role socialization as a possible explanation for the differential effect of the preparation program on boys and girls.

In accord with Koran, Longino, and Shafer (1983), it could be envisaged that the use of novelty-reducing strategies might also be applicable to a broad range of novel settings. It could therefore be surmised that the outcomes of the previously mentioned studies by Delaney (1967), Braverman and Yates (1989), and Fortner and Lahm (1990) may have been influenced by the novelty-reducing effects of the previsit materials used.

Structured/Less Structured Instruction

In a study of the effects of various instructional strategies on the affect of Years 6 to 8 students embarking on a visit to the Kansas Cosmosphere and Discovery Center (KCDC), Finson and Enochs (1987) used an experimental/control group study design and identical pretest and posttest. The KCDC contained, among other things, many hands-on, interactive type exhibits. They found that the students of teachers who used a structured instructional strategy (i.e. provided pre-visit, in-visit, and post-visit activities) or quasi-structured instructional strategy (i.e. any two of the three activities listed previously) attained more positive attitudes towards science-technology-society than students who were not provided with these activities. Their conclusion that such visitations "should be planned and carried out much like well-planned classroom lessons (with set, lesson body, and closure)" (p. 606) is in accord with the recommendation of Price and Hein (1991), the earlier recommendation of Koran, Longino, and Shafer (1983) and the finding of Haladyna, Olsen, and Shaughnessy (1982) that positive attitude development in the classroom correlates with organised instruction.

A somewhat contradictory finding was made by Stronck (1983) in a study of the effect, in both the cognitive and affective domains, of the structure of a tour by Year 5, 6, and 7 students of the Living Land-Living Sea exhibit in the Natural History Gallery of the British Columbia Provincial Museum in Victoria (Canada). A cognitive multiple-choice posttest only (mainly factual questions) and pretest and posttest versions of an attitude questionnaire (equivalent, but with the tense of the verbs changed from pretest to posttest) were used. In comparing the more structured docent-led museum tours (comprising lectures) with the less structured classroom teacher-led tours (with more opportunities for students to enjoy their own explorations without guidance), Stronck found that whereas the former resulted in greater cognitive gain without increasing the positive attitudes of students towards the museum, the latter produced more positive changes in attitude.

Cañizales de Andrade (1989/1990) made a similar finding in the cognitive domain in a study of Year 2 and 3 students visiting a science exhibit. Students who experienced structured visits (i.e. used an activity worksheet that focussed their attention on concepts, displays, and activities) scored significantly higher on a posttest than students who experienced a non-structured visit (i.e. where students interacted with the exhibit according to their own interests). However, any inference from this finding appears limited in the absence of knowledge about how closely the focus of the worksheet activities matched that of the posttest items.

Lucas and McManus (1986), in their preliminary study involving the systematic observation of pupils investigating phenomena in the Discovery Room at the Parc de la Villette, hint at the desirability of providing at least some less-structured time for students in order to achieve what appears to be cognitive outcomes when they comment that "we should not focus only on the intended purpose of an exhibit, but need to be alert to unintended exploratory behaviour, which may be as 'scientific' as the planned possibilities" (p. 351).

Students also provide evidence for the desirability of at least some unstructured time in the study of Birney (1988). The synthesis of survey responses and interview data from Year 6 students making a visit to either the Los Angeles County Museum of Natural History or Los Angeles Zoo shows children implying that learning is inherently enjoyable and that what students describe strongly as their optimal learning experience "resembles [the] researchers' definition of the informal-learning rather than the formal-learning process" (p. 313).

Group Interaction

In Birney's (1988) study, the children "report a preference for companions who allow for an equal exchange of information" (p. 315), in contrast to the managerial role adopted by some adults. Taylor (1986/1987), in a study of the behaviour of family groups visiting the Steinhart Aquarium, concluded that of the three ways in which information flows to visitors--from visitor conversations, from direct observations of the displays, and from the label texts--the most information came to visitors from conversations with their companions (and the least came from the labels).

Diamond (1986) similarly points to the benefits of student-student interaction in a study of representative family groups (comprising both adults and children) visiting the Exploratorium and the Lawrence Hall of Science. These groups were followed, during their visit, by a note-taking observer.

> It appears that learning in a science museum does not occur only or perhaps even primarily as a result of the interaction between individual visitors and the exhibits. There is substantial evidence that social interactions between visitors may be important in stimulating learning at exhibits. (p. 152)

Slisz (1989) also highlighted the benefits of group interaction in another context when concluding that the most effective structures for science fairs provide for both individual and cooperative student projects. Given the extremely limited research available on science fairs, she based her recommendations on an extensive review of relevant literature from a variety of disciplines. While an individualistic structure is very effective in a competition structure over a range of ages (Michaels, 1977) and especially for high ability students (and necessary in the case of competitions in which individual efforts only are accepted), Slisz concluded that a cooperative structure is the most effective for the majority of students. She therefore advocated making provision for both individual and group projects in order to better cater for all students.

Following the same theme, Price and Hein (1991) cited Birney to support the proposition that "programmes that require students to work in teams or pairs capitalize on the fact that students often learn more when they work together, through peer interaction and teaching" (p. 516). This kind of student-student interaction appears to come quite naturally to students. Left to their own devices in museums, children tend firstly to explore by themselves and then to share with others (Carlisle, 1985). Price and Hein also concluded that students who work in small groups (compared with working as a whole class) asked more questions, received more answers, did more hands-on work, and became more involved in their learning. Gottfried (1980) and Tuckey (1992) found that pairs got most deeply involved in activities and Peltz (1990) argued that cooperative learning strategies are beneficial to particularly girls.

Worksheets

Price and Hein (1991) concluded, in their review of PERG evaluations, that "effective programmes use worksheets sparingly, if at all" (p. 515). While worksheets can be used, for example, to focus observation, the PERG experience was that "worksheets too often impede student learning by inhibiting true observation, preventing students from formulating their own questions, and causing students to focus on the narrowly described tasks to the exclusion of broader questions" (p. 515).

On the other hand, Lehman and Lehman (1984) found the provision of questions to older (undergraduate) students useful in achieving cognitive gains associated with one section of the cave exhibit at The Florida State Museum. The students were randomly assigned to one of three groups as they entered the walk-through portion of the cave (containing flora, fauna, and geological displays) before moving to several case exhibits. All students were given induction materials which asked them to observe the cave exhibits and carefully read the case exhibits. However, whereas Group 1 students were not asked to answer any questions about the case exhibits, Group 2 students were asked to answer two experimenter-generated questions (provided in the induction materials), while Group 3 students were asked to generate and answer two questions of their own.

All students were then given an immediate 20-item posttest. While there was no difference found between the performance of groups on those items about the walk-through observation part of the exhibit, Group 2 students performed significantly better than Group 1 students on those questions about the case exhibits. The trend in the results also indicated that Group 2 students performed somewhat, but not as significantly, better than Group 3 students.

Screven (1975) reported the superior cognitive gains demonstrated by off-the-street visitors--mean age 35 years, and visitors estimated to be aged less than 14 years excluded--to Renwick Gallery when a flip booklet, containing statements and questions about an exhibit, was used in conjunction with visitor perusal of an exhibit. "In short, the booklet helped visitors relate to the objects in the exhibit and learn from them" (p. 239). These results from the studies of Lehman and Lehman (1984) and Screven are in accord with the usefulness of adjunct questions which others have used in prose learning to increase learning from text (Rickards, 1979; Shavelson, Berliner, Ravitch, & Loeding, 1974; Watts & Anderson, 1971). Also, the use of programmed cards, by subjects not less than 13 years of age in a museum setting, was found by De Waard, Jagmin, Maisto, and McNamara (1974) to produce significantly more learning than either low information cards or no feedback at all.

Korn (1988) evaluated the use of two different types of self-guiding brochures--one using a traditional declarative technique and the other, including questions, adopting an inquisitive style--in increasing the knowledge of visitors (16 years or older) about Japanese gardens during a tour. While the brochures were shown to enhance learning equally well, Korn interestingly found the declarative brochure to be the more effective in reaching participants who had no prior knowledge of Japanese gardens.

Although worksheets are most commonly designed and viewed as an individualised method of instruction, collaboration does occur. McManus (1985) argued that such collaboration is a desirable feature of a visit to a museum and proposed that a worksheet would be completed better by a group of students (two to four students per group) rather than by an individual. She based this suggestion on her review of the use of worksheets at the British Museum (Natural History) by children up to the age of 15 years, together with data collected via sound recordings of these children at various exhibits. She suggested that this group worksheet approach could have the advantages of increasing the involvement of students and lightening the chore aspects of activities. However, whereas she suggested that groups could appoint one student to be a recorder, it may be preferable to provide experience in this role for all students by sequentially sharing the task of recording between all members of the group. Griffin (1994), in a study of Years 5 to 10 students from 13 schools visiting a science education centre and a museum in Sydney, found that students preferred to complete a worksheet as a group. Maarschalk (1986) provided indirect support for the use of group worksheets by arguing that the type of informal science learning which they encourage assists in the development of scientific literacy.

Time Spent

The research on visitor behaviour, conducted by Falk, Koran, Dierking, and Dreblow (1985) at Florida State Museum of Natural History, involved the tracking of randomly selected visitors. In analysing the data for these visitors over 16 years of age, they concluded that museum fatigue seemed to set in after 30 to 45 minutes. After this time visitor attention to exhibits was observed to drop rapidly, this being accompanied by an increase in attention to the setting. Taylor (1986/1987) also found definite evidence of museum fatigue, a term which he defined somewhat differently in terms of the decreasing time spent at each exhibit as the visit progressed.

Shettle (*sic*, probably Shettel, cited in Kimche, 1978) earlier found that the average visitor (presumably of all ages) toured a complete museum exhibit for a maximum of 14 minutes and Borun (1977) found that museum visits were of two "typical" lengths--2 hours and 3 to 3.5 hours--with an average time of 12 minutes being spent (presumably by visitors of all ages) in each exhibit hall.

The time span of programs evaluated by PERG (Price and Hein, 1991) varied from 1 to 4 hours. Teacher responses indicated that sessions of about 2 hours were best received by both students and teachers. "Shorter periods of time were rarely sufficient for involving students, and longer sessions were difficult . . . for sustaining student interest" (p. 513).

Variety in Activity Type

Price and Hein (1991) concluded that "it is important to offer a variety of activities--hands-on time, demonstrations, films, discussions, and more loosely structured periods--alternating physical activity with periods of sitting and/or listening" (p. 515). Koran and Baker (cited in Price and Hein), in a review of eight fieldtrip studies, similarly conclude that the most effective educational approach includes combined instructional techniques and Linn, Chen, and Thier (1977) report that a combination of free-choice hands-on activities with structured instruction led to more learning by 11- and 12-year-old children than a more laissez faire approach.

Observation Before Concepts, or the Reverse?

In their review of PERG evaluations, Price and Hein (1991) conclude that:

> the more educationally successful programmes begin by providing students with opportunities for first-hand experience and observation, and follow with the introduction of concepts and vocabulary. Some of the less successful programmes have been found to reverse the order, introducing vocabulary and scientific concepts first, then (sometimes) illustrating them through observation. (p. 515)

The former approach is in accord with the implementation of a constructivist approach to the learning and teaching of science (Yager, 1991) in that students are given opportunities to construct their own understanding.

Rewards

Slavin (1984), in his literature review about the use of cooperative learning methods for motivating students to achieve, suggested that students who worked either together or individually for a group reward for individual learning learned significantly more than both students who worked (together or individually) but received no rewards for individual learning and students working (together or individually) for individual rewards. In the case of science fair projects, Slisz (1989) concluded that rewards for student work on science fair projects should be offered, especially in the case of group work. She further recommended that such rewards should be perceived by students to be desirable, should not be money, and could be in the form of social approval.

Conclusions

What, then, is the ideal structure for enrichment and extracurricular science activities? The research evidence suggests that instead of there being a simple single answer to this question, different answers are appropriate depending upon the variables involved, such as the aims of the activity (cognitive or affective), the novelty of the site, and the age of, and intellectual developmental differences between, the participants. To further complicate the picture, there may well be significant differences on these variables between students in a particular participating group of students. Table 2.2 summarises many of the findings of this literature review.

Previsit strategies such as the use of behavioural objectives, test-like items (including a pretest), films, slides, lectures, outlines, supplementary reading, and other advance organisers may all serve to focus attention and provide a beneficial platform for subsequent learning. Teachers should be involved in all aspects of an activity and make a preliminary visit to an unfamiliar venue.

The provision of active, hands-on experiences is especially recommended for younger children and McGlathery and Hartmann (1973) give some examples of inquiry-oriented activities in the museum context. In unfamiliar environments, the use of introductory novelty-reducing strategies may improve the on-task involvement of students and hence some associated cognitive and affective outcomes. While more structured instruction may produce better cognitive gain, less structured instruction may produce better gains in the affective domain and may also result in unintended cognitive gains. The most appropriate compromise, in the case of a learning experience involving both cognitive and affective objectives, may therefore be to make provision for both types of activity. This is compatible with the desirability of providing varied types of activity (each no longer than 0.5 hour or so, but shorter than this with younger students) for participants during a particular learning experience.

Small group work (possibly pairs) provides for student-student interaction, a very useful mechanism for promoting learning. For older students, group (as opposed to

Table 2.2
An Overview of the Effectiveness of Various Strategies in Implementing Science Activities

Strategy	Domain: Cognitive	Domain: Affective
Orientation and previsit strategies		
Younger (e.g. primary) students	✓	?
Older students	✓	?
Active (compared to passive) participation		
Younger (e.g. primary) students	✓	?
Older students	✓	?
Novelty-reducing strategies		
Younger (e.g.primary) students	✓	_
Older students	✓	✓
Structured (compared to less structured) instruction		
Younger (e.g. primary) students	✓	Somewhat contradictory findings
Older students	✓	
Group interaction		
Younger (e.g. primary) students	✓	_
Older students	✓	_
Worksheets		
Younger (e.g. primary) students	x	_
Older students	✓ (& group worksheets)	_
Time spent and variety in activity type	Up to about 2 h (depends on site), but with shorter varied activities	
Group reward for individual learning		
Younger (primary students)	✓	_
Older students	?	_

Key:
✓ = evidence for its usefulness
x = use sparingly or not at all
? = perhaps useful
_ = no relevant information

individual) worksheets can promote such interaction while enhancing cognitive outcomes by focussing student attention.

While this discussion of effective learning and teaching strategies is restricted predominantly to the findings of structured research, the literature also contains further suggestions for such strategies based less on structured research and more on evidence such as personal opinion and anecdotal feedback. Hoke (1991), for example, suggests that the attention span of students (presumably for a single type of activity) can be estimated by multiplying a child's age by four (i.e. 48 minutes for a 12-year-old), Balson (1973) gives examples of follow-up work in the classroom which he suggests can assist knowledge retention and motivation, and Pratt (1973) regards a detailed report as one of the best ways to derive maximum benefit from an outing. Such contributions are not addressed in this literature review.

Because some of the reviewed findings are contradictory, care must be taken in generalising from them. There are many variables involved in studies such as these and no two of the reviewed studies adopted methodologies which dealt with precisely the same variables. Take, for example, the superior effect on boys only of the novelty-reducing programme reported by Kubota and Olstad (1991). Would the effects have been different if a centre with biology-oriented exhibits rather than physics-oriented ones had been visited? Would a change in the structure or type of advance organiser significantly change the outcomes of a learning experience? Horton et al. (1993) expose this temptation to over-generalize when, in an analysis of some relatively recent studies, they conclude that "many researchers . . . do not properly restrict their conclusions based on the limits imposed by the accessible populations and samples used" (p. 857). Also, as Price and Hein (1991) warn:

> Traditional tests have been criticised as inappropriate for assessing the variety of complex skills associated with 'doing science' . . . . A number of newer assessment approaches are currently being developed including 'hands-on' tasks for students to perform . . . interviews with children and children's conversations . . . and other performance-based measures. (p. 510)

Further, different methodologies may lead to different conclusions. Eason and Linn (1976), for example, observed Years 5 through 8 students to demonstrate improved academic gains in test situations where the questions were presented in diagrammatic rather than written form (although this effect was more pronounced with the younger students) and Borun, Flexer, Casey, and Baum (1983) concluded that researchers at two different institutions, working on a joint project, obtained different results when they used different methodologies and defined science learning in different ways.

Finally, it appears obvious that attention to structure alone, even if it could appropriately address the many variables mentioned previously, will not guarantee an effective learning experience. Many other factors are undoubtedly involved, as is exemplified by the study of Fletcher (cited in Mallon & Bruce, 1982) which indicates that instructor personality was more important than instructional technique in achieving cognitive gain as a result of a planetarium visit.

Although interest in informal science learning has increased during the last 25 years, most studies focus on arguments for the importance of such learning experiences or on descriptions of programs in museums; very few involve research of the process of learning science outside the classroom (Lucas, 1991). There appears much room for further research in the latter area, including research aimed at determining preferred structures for maximising affective outcomes from science enrichment and extracurricular activities.

2.8 Effects of Activities: Conclusions

The literature contains evidence that science enrichment and extracurricular activities such as visits to museums, science centres, and institutes, practical work, and tutor programs can have positive effects on students' interest and enjoyment in being involved in science activities, their motivation to continue to participate in science, and their perceptions about scientists (section 2.6). However, the reported outcomes from an activity may vary with the measuring technique used to determine them (e.g. Sneider, Eason, and Friedman, 1979) and the structure of the activity (section 2.7). Also, when interpreting the results for an activity involving volunteers, one needs to be aware of the possible presence of a ceiling effect (i.e. the students who choose the activity may have very high prior attitudes towards it, making the detection of increases in such attitudes unlikely).

Nearly all of the studies reviewed have been concerned with the short-term affective outcomes of participation in individual activities. As Henry (1984) showed, in research designed to evaluate the effectiveness of developed teaching material in changing Year 10 students' views of science and scientists, significant positive short-term changes in students' views of aspects of science do not necessarily translate into longer-term changes; students can revert to their initial views. There does not appear to be any longitudinal studies which have monitored the longer-term influences of activities.

While in an overall sense relatively little research appears to have been directed towards monitoring the affective outcomes from participation in science enrichment and extracurricular activities, some of the activities being focussed upon in this study appear never to have been subjected to such scrutiny. This study addresses these needs.

CHAPTER 3

Research Design

3.1 Design of the Study: An Overview

The aim of this research was to study the influences of a program of enrichment and extracurricular science activities on students' affect, defined as the students' interest and enjoyment in being involved in science activities, their motivation to continue to participate in science, and their perceptions about scientists and about the role of science in society. In particular, the research focussed on how each of these affective variables changed during 2.5 years of secondary education, why they changed, and what effects student participation in the enrichment and extracurricular activities had on these variables. Table 3.1 summarises the enrichment and extracurricular science activities available to students at Glendale College, and appendix 3.A contains a more detailed description of each activity, including any pre- and post-activity exercises. Where possible, the activities were designed with those results of the literature review of section 2.7 which were available at the time in mind. This was not possible in cases where the structure of the activity was beyond the control of the researcher, such as competitions and excursion activities for which the structure was pre-determined by external personnel and activities for which the autonomy of other teachers needed to be respected.

A quasi-longitudinal case study research design involving both qualitative and quantitative methods of data collection was chosen. As Piburn and Baker (1993) note, the qualitative case study approach is well-suited to attaining a description of students' perceptions from their own point of view. It allows the researcher to get close to the subjects and thereby access subjective qualities such as their thoughts, feelings, and desires.

The choice of a quasi-longitudinal approach appeared to be a satisfactory compromise in view of the fact that while there is the need to study longer-term perceptions, following a student cohort for a 5-year period (as would be required in the case of a fully longitudinal study) was beyond the time available for a doctoral study. A Year 8 cohort, subsequently called the *junior cohort,* was followed from the

Table 3.1
Enrichment and Extracurricular Science Activities: An Overview

Year	Activity
8	Australian Schools Science Competition (June)[a], Science Contest Excursion (August), Planetarium Excursion (August)
9	Mine Excursion (Term 2, Year 9 students, 1993), Museum Excursion (Term 2, Year 9 students, 1991), *Sciencentre* Excursion (Term 2), Investigation (Semester[b] 1), Australian Schools Science Competition (June)
10	A.S.I.A. Science Summer School[E] (January vacation), Poster Competition[E] (Semester 1), Australian Schools Science Competition[E] (June), National Chemistry Quiz[E] (July), USQ Engineering and Surveying Seminar[E] (August), Primary Interface[E] (an explainer program, Semester 2)
11	Australian Schools Science Competition[E] (June), National Chemistry Quiz (July), Queensland School Geology Competition[E] (July), R.A.C.I. Schools' Lecture (August), Youth Physics Lecture (August), Work Experience[E] (End Term 3), Biology Olympiads[E] (Term 4), CRA National Science Summer School[E] (End of year)
12	CSIROSEC Excursion (Term 1), Physics Investigation (Terms 2,3), USQ Engineering and Surveying Seminar[E] (May), Australian Schools Science Competition[E] (June), Biology Investigation (Term 3), Chemistry Investigation (Term 3), National Chemistry Quiz (July), R.A.C.I. Schools' Lecture (July, but not offered 1994), Youth Physics Lecture (August), Work Experience[E] (Any vacation)
Across years	CSIRO Student Research Scheme[E] (All year), CSIRO Talk to a Scientist[E] (All year), Evening Science[E] (All year), Evening Science With a Guest[E] (periodically throughout the year), External science competitions[E] (e.g. Qld. Science Contest [August], BHP Science Contest), Science Club[E] (All year), SPECTRA Awards[E] (Years 8 and 9, all year), Vacation Science Tour[E] (December)

Note. [E] indicates an extracurricular, as distinct from an enrichment, activity. [a]Indicates the time of year the activity was offered and/or conducted. [b]Each school year was divided into two approximately equal-length semesters, and each semester comprised two terms.

beginning of their Semester 2 through to the end of Year 10, while another group, the *senior cohort*, was simultaneously followed from the beginning of their Semester 2, Year 10 till the end of Year 12.

More detailed data were collected from a subsample of students from each of these cohorts. Two groups of 10 students (five girls and five boys) were selected to form the *junior* and *senior samples*. This decision stemmed from the view that a population of 20 students would provide a manageable data collection and analysis task, while at the same time being large enough to allow a reasonable level of confidence to be associated with the synthesis of conclusions and the transferability of findings. Equal numbers of girls and boys were chosen in each cohort to allow gender-related considerations, if any, to emerge. In any case, this male-to-female ratio is similar to the ratio of approximately 1.3:1 that existed at the school during the study period.

Data collection involved interviews, surveys (including attitude scales), written records, and observations. Because similar data were collected on several occasions, care was needed to collect sufficient data from the students without them becoming bored. In particular, the interviews and surveys provided for the triangulation of data relating to changes in each dependent variable (namely, students' interest and enjoyment, motivation, and perceptions about scientists and the role of science in society), thus assisting to establish the internal validity of findings in these areas (Muralidhar, 1993). Further, Guba and Lincoln (cited in Merriam, 1988) state that since "it is impossible to have internal validity without reliability, a demonstration of internal validity amounts to a simultaneous demonstration of reliability" (p. 171).

The research design has some advantages. First, no manipulation of the situation was required. This was a necessary feature because the implementation of an alternative experimental design requiring, for example, a control group, was not possible in the school. Second, the inclusion of a series of interviews addresses the challenge in evaluating informal learning as articulated by Friedman (1991):

> Longitudinal studies are apt to have a hard time separating out the effects of museum visits from other important factors, such as the presence of teachers and parents supportive of museum visits and other informal learning experiences. (p. 422)

Finally, a potential disadvantage associated with the methodology concerns the possibility that the data collection processes (and especially the interviews), by acting in a de facto way as extracurricular science activities, may have an effect of their own on student affect, thereby changing the variables they were being used to measure. Part of the interview process, described more fully in section 3.5, was devoted to monitoring this potential disadvantage.

3.2 The Researcher in Context

During the study period, the researcher was one of the male teachers at Glendale College, also serving as Head of Science. As such, he taught most of the students selected to be involved in the study. At the beginning of the study period, he had over 15 years science teaching experience in a number of Government and Independent schools, over 10 of these as Head of Science at Glendale College.

His beginning-teacher qualifications were a Bachelor of Science (with first-class honours in physical chemistry) and a Diploma in Education. During his teaching career, he had taken an active and continuous role in updating his professional education skills by enrolling in university subjects and attending appropriate seminars and conferences. He had also served as both a district and State physics panel member (subject panels in Queensland are responsible for the accreditation of school workprograms and the monitoring and certification of student achievement), a Physics Syllabus Committee member, a science journal and physics software project reviewer, and was the author of a number of science education publications.

The researcher had been responsible for the design and implementation of many of the activities forming the focus of this study and therefore had an interest in (and, as Head of Science, a responsibility towards) monitoring the outcomes generated by the activities.

3.3 Initial Student Sampling

Student sampling was conducted so as to ensure that, after attrition, data for 20 students were available for analysis. These 20 students comprised 10 junior and 10 senior students, with equal numbers of girls and boys in each group.

Year 8 Students

During August 1992, each of the 48 Year 8 students at the college responded to a survey question (see appendix 3.B, section 2) by placing a cross in one of three boxes, to determine the likelihood they would stay at Glendale College until the end of Year 10, the end of the study period. Of the three possible student responses, *very likely*, *not sure*, and *probably not*, the students who responded *very likely* were identified.

The Year 8, Semester 1 science achievement of these students was then considered. This achievement had been recorded as letter grades A to F, described as *excellent*, *good*, *satisfactory*, *moderate only*, *below acceptable standard*, and *subject is beyond the student*, respectively. Grades of A to C were generally considered pass level. Students with grades of D or below were deleted from the sample because it was likely that many, if not most, of them would exit Science and select Science for Living the following year, thus missing at least some opportunities to participate in the enrichment and extracurricular science activities available during Years 9 and 10. One further student was also deleted as he was a late arrival at the College and had missed some Year 8 activities. Twenty students remained in the group; coincidentally, 10 girls and 10 boys.

Girls. The researcher met with the 10 girls individually, asking them about their willingness to participate in half-yearly or yearly interviews and about any difficulty, such as personal conflict or a feeling of uncomfortableness with the interviewer (the researcher), that they perceived might inhibit the interviewing process. These meetings also provided the opportunity for the interviewer to note any other potentially inhibiting factors such as extreme shyness. Three girls were excluded because one was absent from an excursion conducted earlier in the year, a second indicated she may now soon leave the College (family reasons), and a third was uncertain about her willingness to participate in the research program. The remaining seven girls were retained as the initial sample, thus providing scope for attrition.

Boys. The 10 boys were similarly interviewed and three excluded. Two indicated that they may now no longer remain at the college for the duration of the study period and another was deleted on the basis that his extracurricular science participation had been restricted to one activity only (an activity which was well represented in the activities of the remaining boys), his science achievement showed a downward trend from a C grade at the end of Semester 1, and his removal gave an initial junior sample of seven, identical to the girls.

Year 10 Students

During the same month, each of the 58 Year 10 Junior Science students at the college were similarly surveyed for their opinion as to the likelihood of them staying at the college until the end of Year 12 but also about the likelihood of them studying each of Biology, Chemistry, and Physics in Year 11. From the students who responded *very likely* to the former, those who indicated that they were either *certain* or *very likely* (from the choices *certain, very likely, not sure, probably not,* and *definitely not*) to study Chemistry and Physics in Year 11 were chosen. The emphasis on Chemistry and Physics was due to the fact that, at that time, these two senior science subjects provided the enrichment science activities in Years 11 and 12. This resulted in a sample of eight students, each of whom, when approached individually, agreed to participate in the study. Two further willing *very likely to remain at the College* students were added to the group in order to attain a sample size of 10. They were the next two students most likely to participate in a senior science. This initial sample comprised four girls and six boys.

This sample was reviewed, following first-round interviews at the end of 1992, early in Year 11. At that time, which students had actually enrolled in each senior science was known and consideration was given to the addition of new Year 11 enrolments to the senior sample. The resulting changes to the sample are described in section 3.6.

3.4 Written Data

A written record was kept of the participation of every junior and senior cohort student in enrichment and extracurricular science activities throughout the entire study period. Three survey instruments were administered to all junior and senior cohort students on three occasions during the study period; August-September 1992, November 1993, and November 1994. On most occasions they were completed by students in supervised class time. When this was not possible (mainly in the case of senior-cohort students), the surveys were completed by students "in their own time."

Rating scales. Each cohort member was asked to rate, by placing a cross on each of three linear 0 to 10 scales, their interest and enjoyment in being involved in science activities, their motivation to continue the study of science, and their view of the importance of science in society. When used with the Year 8 cohort in 1992 only, students were helped, by way of verbal synonyms, with interpretation of the terms *motivation* and *society.* In other instances, students relied on their own intuitive definitions of these variables. The scales are shown in section 1 of the survey form of appendix 3.B.

TOSRA. Student results on each of five of the seven Test of Science-Related Attitudes (TOSRA) scales, each containing 10 Likert-type items, were recorded. These scales were given to all students in the year cohort. The five scales used were Scale S, Social Implications of Science (a measure of attitude towards the social benefits and problems which accompany scientific progress and exemplified by the item "Money spent on science is well worth spending."); Scale N, Normality of Scientists (a measure of an appreciation that scientists are normal people rather than the eccentrics often depicted in the mass media, exemplified by the negatively-worded item "Scientists usually like to go to their laboratories when they have a day off."); Scale E, Enjoyment of Science Lessons (exemplified by the item "Science lessons are fun."); Scale L, Leisure Interest in Science (exemplified by the item "I would like to belong to a science club."); and Scale C, Career Interest in Science (exemplified by the negatively-worded item "I would dislike being a scientist after I leave school."). The other scales, Attitude to Inquiry and Adoption of Scientific Attitudes, were not used because they would not provide information relevant to the research questions. Table 3.2 gives the Cronbach α coefficients, a measure of internal consistency reliability for the items on each scale administration. These values, similar to those reported by Fraser (1981), suggest quite good internal consistency reliability throughout, with only the junior Year 9 Scale N result somewhat low at 0.60. Of the 30 results, 22 equal or exceed 0.80.

Course interest. A five-statement Course Interest Survey, adapted from Burr (1985), was used for all science subjects at all year levels. For each statement, the student placed a cross in one of five boxes representing different degrees with which

Table 3.2
Cronbach α Coefficients for Scales on the Test of Science-Related Attitudes

	Cronbach α coefficient				
Cohort	Scale S	Scale N	Scale E	Scale L	Scale C
Junior					
Year 8 (*n* = 48)	.78	.75	.89	.84	.90
Year 9 (*n* = 43)	.83	.60	.84	.77	.82
Year 10 (*n* = 42)	.76	.73	.83	.82	.82
Senior					
Year 10 (*n* = 68)	.75	.79	.91	.85	.86
Year 11 (*n* = 27)	.86	.84	.91	.83	.89
Year 12 (*n* = 21)	.80	.84	.87	.84	.90

Note. These data are based on all students in a given cohort studying a science subject and not the sample students alone.

the student could agree with the statement. The statements dealt with looking forward to science classes, enjoying the homework and study associated with science, enjoying work in the classroom, feeling a sense of satisfaction after a science lesson, and recommending science to future students. The form shown in appendix 3.C, used with Years 8, 9, and 10 students, had the word *science* replaced with the appropriate senior science (biology, chemistry, or physics) when used with senior cohort students in 1993 and 1994.

Table 3.3 shows how the results of these surveys contributed to the triangulation of data concerning changes in each dependent variable. Each dependent variable is defined primarily in terms of each student's intuitive definition of the variable, assisted by some verbal elaboration by the researcher, in the form of alternative phrases, during mainly interviews. For example, students were asked about the influence of

Table 3.3
A Summary of Data Triangulation for Each Dependent Variable

	Data-collection technique			
	Surveys			
Dependent variable	Rating scales	TOSRA	Course interest	Interviews
Interest and enjoyment	✓	Scales E, L	✓	✓
Motivation	✓	Scale C		✓
Perceptions about scientists		Scale N		✓
Role of science in society	✓	Scale S		✓

participation in an activity on their motivation to continue to participate in science by means of "What effect, if any, did this activity have on your desire to continue your study of science (that is, later on, past Year 10 or past Year 12)? Did it spur you on or put you off?" Each TOSRA scale and the Course Interest Survey define the dependent variables operationally, often in a different way. For example, TOSRA Scale C statements revolve predominantly around the notion of becoming a scientist. A student could have a relatively low score on this scale yet have a very high motivation to continue to participate in science, perhaps as a result of their desire to pursue a science-based profession other than that of a scientist. Also, a student could have a very high interest and enjoyment in being involved in science without necessarily scoring highly on TOSRA Scale L, Leisure Interest in Science or experience changes in their perception of scientists other than that measured by TOSRA Scale N, Normality of Scientists. However, despite these limitations, it was considered that these scales provided the best available aid to triangulation, could provide useful additional data to monitor changes in each dependent variable, and that their limitations could be acknowledged, as necessary, during data analysis. In interpreting TOSRA data, the advice of Fraser (1981) was used to regard only changes which approach 1 unit on the 10-unit scales to be of practical significance. One should also note that the reliability and construct validity of TOSRA were established by Fraser in terms of groups of students and not, as used in this study, for individual students.

It was expected that sometimes trends in the data for a particular dependent variable would be inconsistent (Mathison, 1988). Davis (cited in Powell & Cracknell, 1987) expressed well the potential for students' retrospective perceptions over the longer term to differ from trends in the quantitative data which were collected periodically:

> So memories die, and merge, and absorb foreign images; they change. Later memories alter earlier; new experiences breed new ideas, new values. We are always at the business of re-interpreting our sense of reality, and the latest interpretation is apt to wipe out its ancestors, and to distort the memory of the evidence on which they are based. (p. 109)

Where the data were contradictory, appropriate recognition is therefore given to the student's retrospective perceptions as it is considered that these would best reflect the latest and fullest perceptions of the student.

Other Data Collected

At the end of each of 1992, 1993, and 1994, every junior and senior cohort student was surveyed to determine their reasons for either choosing or not choosing to participate in the extracurricular (voluntary) science activities which had been available to them during the year. Each survey form was completed without collaboration and during class time, and appendix 3.D contains a copy of the form used with Year 8 students in 1992.

During Term 4, 1994, written demographic data, comprising day student/boarder status, position in family, parents' occupations, date of birth, and previous school experience, were obtained from every sample student using the form shown in appendix 3.E. At the end of 1994, future contact details for each sample student were obtained, as well as a copy of each of these students' Record of Progress card, containing details of their achievement, effort, and conduct and cooperation in each subject studied at the college.

A Draw-A-Scientist Test was considered but, on the basis of the concerns expressed in chapter 2 (and especially the potential lack of validity of the instrument) was not used to gather information about students' perceptions of scientists. This decision was subsequently justified, with interview data confirming, for example, that one student held two distinctly different perceptions simultaneously.

3.5 Interviews

Introduction

The composition of the junior and senior sample groups of students varied from year to year, and details of these changes are reported later. However, the students who constituted the sample groups at the time of interview were interviewed, and the interviews audiotaped with permission, during November 1992 (Round 1), November 1993 (Round 2), and October-November, 1994 (Round 3). Table 3.3 also shows how the results of these three rounds of interviews contributed to data triangulation.

Interviews varied in length from a minimum of approximately 20 minutes to a maximum of approximately 55 minutes. Students were asked to rate their interest and enjoyment in being involved in science activities, their motivation to continue their study of science, and their view of the importance of science in society. They were asked to describe their senior science subject, career, and/or tertiary course thoughts and their view of scientists and the role of science in society. They were also asked to describe any changes to any of the dependent variables since the previous interview, including the influences on these variables of participation in science activities, with each science activity in which they had participated being addressed individually. During the interviews it was found that repeating a question in different words did, on a significant number of occasions, elicit further student response. Such alternatives are exemplified in the interview schedule of appendix 3.F.

It was not practicable to conduct interviews off the college campus, at "neutral ground," random locations. Rather, rooms were used on the College campus which were geographically removed from rooms associated with science education and which were not used for teaching purposes. A relaxed and conversational atmosphere, devoid of the sense of formality which can be associated with interviewing, was aimed for during each interview. The researcher wore usual school dress, but without a tie. In addition to adopting the advice of Lythcott and Duschl (1990) to show an interest in the student's meanings instead of searching for an answer which will be assessed with respect to some external criterion, to use follow-up questions to explore reasons behind a student's initial answer in such a way as to avoid "leading" the student, to explore doubt and hesitation, and to be sensitive to contradictory responses, the researcher was careful to avoid giving any verbal or non-verbal disapproving cues during interviews, thus aiming to avoid students feeling threatened.

Trial Interviews

The suggestions of Merriam (1988) and Todd (1979) were used in the construction of a draft interview schedule; in particular, the desirability of establishing a relationship with interviewees which informs them about the purpose of the interview and tries to give them a reason to feel relaxed and to want to cooperate, and the value of assuring the confidentiality of student responses in encouraging students to feel comfortable and confident about being honest and complete in their remarks. This schedule was used for the trial interviewing, in September 1992, of two Year 9 students (one male, one female) and two Year 11 students (a male studying Chemistry and Physics and a female studying Biology and Physics). These students, one year ahead of the respective student cohorts participating in the study, were subsequently questioned about the structure of their interview. As a result, the interview schedule was modified slightly in preparation for the first round of interviews.

The trial interview schedule required that students receive, at least one week prior to their interview, a Focus of the Interview handout (appendix 3.G) which summarised the information being sought during interview. Following discussion with the trial interviewees after their interviews, it was decided to use the handout with Year 10 sample students, but not Year 8 sample students, during first-round interviews. Both Year 9 trial interviewees suggested that the younger Year 8 students might survey the thoughts of peers prior to interview. As one said, "they will just ask other students what to say." In contrast, the older Year 11 trial interviewees did not hint at this possibility, with one student suggesting that the prior issue of the handout would allow the students to "get ready for what the interview's on." For this reason, it was decided that the prior issue of the handout to the older students could increase the quality of their contribution.

Interview Schedules

First round. As first-round interviews were being conducted, it became evident that some additional questions were required and a follow-up round of interviews was conducted early the following year in order to obtain this additional information. For example, students who participated in Evening Science or Science Club were asked to describe what tasks they had undertaken during these activities, students were asked if they had participated in particular activities on a previous occasion, and, in the case of a student receiving an award, if receipt of the award had influenced them. These follow-up interviews also allowed the overcoming of difficulties with analysis of the first-round interview tapes, such as inaudible or incomprehensible words. The resulting composite interview schedule for Year 10 sample students is given in appendix 3.F. It should be noted that, as part of these interviews, each student was again asked to complete the Rating Scales described in section 3.4 and shown in section 1 of appendix 3.B.

An analogous schedule was used with the Year 8 sample students with one notable exception, in addition to not issuing a Focus of the Interview handout. No information was sought in relation to senior science subjects because such choices were 2 years away, the students had only relatively recently commenced secondary science education, and the researcher did not want to appear to be pressuring students into deliberating about a matter which would probably be of little relevance to them at that time.

Appendix 3.H contains the transcript of the first-round interview with Alex, a senior cohort student. This transcript exemplifies the approach taken to interviewing. All other student interviews, for all rounds of interviewing, were logged; a different process to transcription in that major details only were summarised. Appendix 3.I contains a sample log, representing the second-round interview with Zita, a junior sample student.

Second round. A modified Focus of the Interview handout (appendix 3.J) was given to both Year 9 and Year 11 sample students about a week before their interview and the flavour of the interview schedule used mirrored the first-round schedule, with the following significant changes.

Year 11 students were asked how their career and/or tertiary course thoughts had changed, if at all, since their last interview. The key points they made in this area during the first interview were used as prompts. The Year 9 students were asked about any career, tertiary course, or senior-science-subject thoughts they had. In addition, both groups of students were asked about the effects of enrichment and extracurricular science activities in these areas.

Both student groups were also asked about changes in their interest and enjoyment in being involved in science activities, their motivation to continue their study of science, their view of scientists, and their view of the role of science in society since their last interview. Where appropriate, the degree of such change (little, medium, or a lot) was also sought. In the latter two areas, students' comments during their previous interview were used as prompts.

Finally, longer-term effects (both positive and negative) of science activities were explored by asking students about any effects which the activities focussed upon during the previous year's interview were still having at this time. In particular, effects on students' interest and enjoyment and motivation were sought. As introduced in chapter 2, longer-term effects are, for the purposes of this study, effects which are present about 1 year or longer after an activity.

Third round. The Focus of the Interview handout used here was basically the same as that distributed prior to second-round interviews, with the only major difference being that Year 12 students were asked to think about the reasons for any changes, since the previous year's interviews, in science subjects studied.

The interview schedule used also mirrored that used for second-round interviews, with the following significant change. Each student received, in conjunction with their Focus of the Interview handout at least a week prior to interview, a copy of a Graphs of Retrospective Trends worksheet developed by the researcher. Figure 3.1 shows the worksheet given to junior sample students. For senior sample students, Years 8, 9, and 10 on this worksheet were simply changed to Years 10, 11, and 12. Students were asked to reflect upon trends in their interest and enjoyment in being involved in science activities, their motivation to continue their study of science, and their view of the importance of science in society during the previous 3 years and to draw, on their worksheet and in their own time prior to interview, line graphs to represent trends in each of these variables during that time. During their interview, these graphs were

Graphs of Retrospective Trends

Using the grids below, draw rough line graphs to show how:

(a) your interest and enjoyment in being involved in science activities,

(b) your motivation to continue your study of science, and

(c) your view of the importance of science in society

have changed during your secondary school life.

(Zero is the lowest rating on each scale and 10 is the highest.)

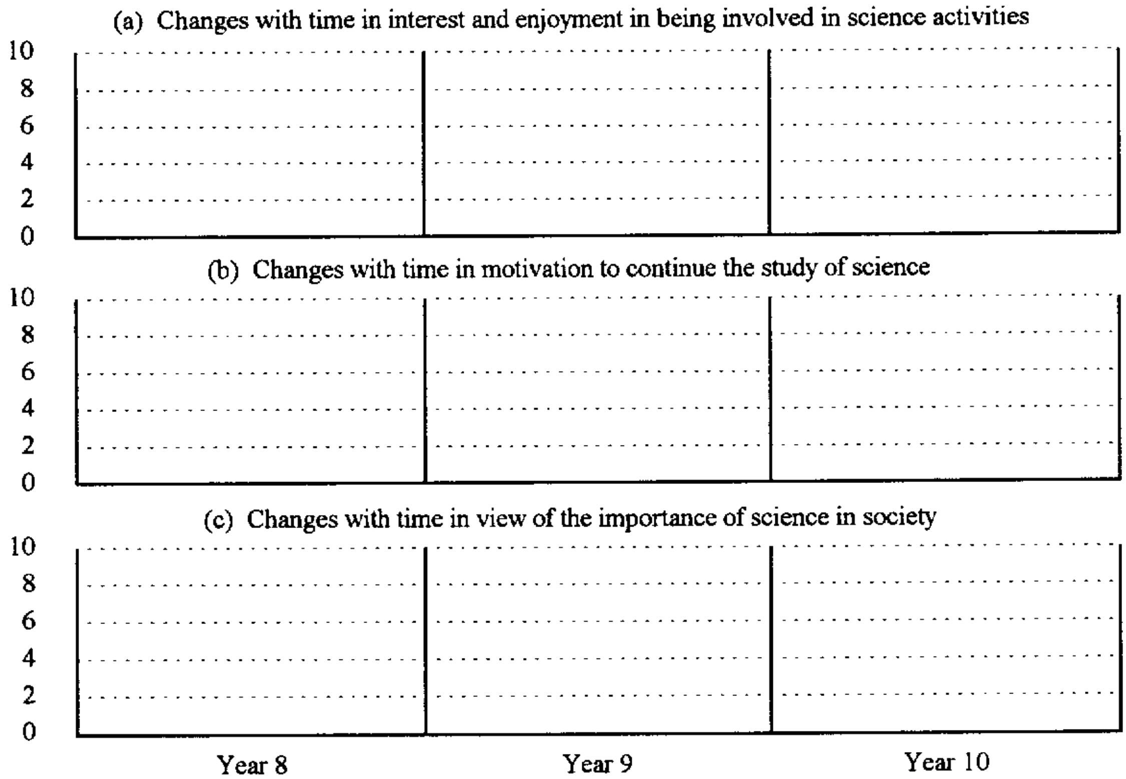

Figure 3.1. Graphs of Retrospective Trends worksheet.

used to focus questions. In order to cater for students who were added to the student samples subsequent to initial sampling, second- and third-round interview schedules were appropriately modified.

Checks on Validity

Two strategies were used as checks on the internal validity of interviews. First, at the end of third-round interviews, each student was asked if the yearly interviews during the study period had had any effect on them, particularly in regard to their interest and enjoyment in being involved in science activities or their motivation to continue their study of science. This was done to ascertain, for example, if the interviews themselves, by acting as extracurricular science activities, may have changed the variables they were being used to measure. Every junior and senior sample student said that the interviews had no effect on each dependent variable. However, one student related that while he was doing an activity, previous experience in the interview process made him think about the types of questions he knew he would be asked at his next interview. This raises the possibility that the interview process may have influenced to some degree the effects of activities on students, but this is an unavoidable limitation of the methodology adopted.

Second, after third-round interviews, four students (a junior male and female and a senior male and female) were chosen randomly to complete the Feelings About the Interviews survey (appendix 3.K). Students responded, in writing, to five questions aimed at investigating aspects such as the honesty and accuracy of their responses and their comfort level during interviews. The survey was completed in the students' own time and anonymously, with students also being invited to type their responses if they felt that they would be more comfortable expressing their honesty in the absence of potential hand-writing identification. In the case that feedback identified difficulties, it was planned to survey further students. This proved unnecessary. All four selected students responded to this survey in their own handwriting and all expressed a high degree of comfort about being honest, accurate, and complete in their responses.

3.6 Sample Changes

Junior Sample

The initial junior sample (Year 8 students) comprised seven girls and seven boys. During Year 9, one of these girls left the college, leaving the remaining students to participate in second-round interviews. During Year 10, three further girls left the college. Two other girls (Angela and Rebecca), the only two who had been at the college since the beginning of Year 8 and who were awarded an achievement grade of *C* (satisfactory) or better in Science for Semester 1, Year 10, were therefore added to the sample to bring the total number of girls up to five.

Following third-round interviews, two boys were removed from the sample in order to arrive at the five-girl/five-boy sample required for data analysis. One boy left the college and did not reply to a letter asking about his subsequent science enrolment and the other was removed because he chose to study only Biology as a senior science and there were two other students in the sample with similar profiles.

Senior Sample

The initial senior sample (Year 10 students) comprised four girls and six boys. Early in Year 11, one girl and one boy were removed from the sample because they did not choose to study any senior science subjects. Six girls and four boys were added, with those students new to the college asked to complete appropriate survey forms. Subsequently, on the basis of Semester 1 achievement and subject changes, three girls and one boy were removed from the sample, leaving six girls and eight boys to participate in second-round interviews.

During Year 12, one further girl was removed from the sample after she no longer continued to study a senior science, leaving five girls to participate in final-round interviews. Following these interviews, three boys were removed from the sample to likewise give the required five needed for the data-analysis phase of the study. The first had a profile similar to three others in the sample and interviews in which he was not very talkative, the second was a student who had joined the college only in the previous year, and the third was a student whose post-secondary destination was not known and who also had not been very talkative during interviews.

3.7 Observations

The researcher attended, where feasible, each activity which was part of the study, observing the setting, participant behaviour, activities, and interactions. In other cases, observations were sought from an attending teacher. A record was also kept of relevant information about students made during staff meetings and in Principal's memos to teaching staff, such as comments about cooperation with others, application to tasks, and social differences between peers. The response by organisers to the competitions they conducted was also noted.

It was the feeling of teaching staff, most prominent during Year 9, that the junior cohort was characterised by atypically low median academic achievement and effort.

At the same time, this group did contain a number of high-achieving, talented, and motivated individuals. The college's Pastoral Care Committee documented the abnormally high degree of social-interaction difficulties experienced within the group, and any anti-school attitudes which permeated this group could easily be envisaged to manifest themselves in attitudes to science as well.

3.8 Data Analysis: An Overview

The information in student interview logs was combined with written data to produce three phases of data analysis. Phase 1 involved summarising in case study format, for each of the final 20 sample students, how and why their interest and enjoyment in being involved in science activities, their motivation to continue to participate in science, and their perceptions about scientists and about the role of science in society changed during 2.5 years of secondary education and what effects participation in enrichment and extracurricular activities had on these variables. Chapters 4 and 6 contain these case studies for junior sample and senior sample students, respectively.

In Phase 2, each of these dependent variables was considered in turn. Data from all 20 sample students were used in a search for generalisations about changes in each variable, including how and why they changed. During Phase 3 of the analysis of data, each enrichment and extracurricular science activity was considered in turn in terms of its effect on each dependent variable. The results of Phases 2 and 3 of data analysis are given, for the junior sample and senior sample, in chapters 5 and 7, respectively.

CHAPTER 4

Case Studies: Junior Sample

4.1 Introduction

This chapter contains the results of the first phase of data analysis for junior sample students. Girls are treated first, followed by the boys. For each group, students' biographical data and participation in enrichment and extracurricular science activities are summarised. Then, the quantitative data from each survey instrument administered, plus the Rating Scales completed during interviews where applicable, are tabulated for each dependent variable. Each case study is then presented, finishing with an overall summary of the data for the student.

In the main body of each case study, each dependent variable (i.e. interest and enjoyment in being involved in science activities, motivation to continue to participate in science, and perceptions about scientists and about the role of science in society) is considered in turn. For the three variables for which it is appropriate, the trend through the study period is identified (e.g. interest and enjoyment increased) using the Graphs of Retrospective Trends and the other quantitative data contributing to data triangulation. Because students' perceptions about scientists can be broader than that measured by TOSRA Scale N (Normality of Scientists) alone, this variable does not lend itself to analysis in terms of a quantitative trend. Where the data are inconsistent, appropriate recognition is given to the student's retrospective perceptions because it is considered that these would best reflect the latest and fullest perceptions of the student.

The factors influencing all dependent variables are described. In line with the research questions, the effects of student participation in enrichment and extracurricular science activities, and the cause of any longer-term effects on the dependent variables, are reported.

4.2 Background Information: Junior Girls

Biographical Details

Table 4.1 summarises the biographical details of the junior sample girls. The achievement ratings (A to F) given in Table 4.1 were defined in section 3.3. The effort ratings used by the College ranged from 1 to 5, defined as *excellent*, *good*, *reasonable*, *poor*, and *no real voluntary effort*, respectively. The ratings for conduct and cooperation also ranged from 1 to 5, defined as *excellent*, *good*, *satisfactory*, *needs improvement*, and *well below acceptable standard*, respectively.

Participation in Activities

Table 4.2 summarises participation, in chronological order where appropriate, by junior sample girls in the enrichment and extracurricular science activities. Only those activities experienced by sample students are listed, and they do not include all activities offered; no girls, for example, chose to participate in, or nominate for selection for, some activities.

4.3 Some Quantitative Data: Junior Girls

Tables 4.3 to 4.6 report the quantitative data from each survey instrument administered, plus the *Rating Scales* completed during interviews where applicable, for each dependent variable. For consistency, the scores on all scales given in the tables have been converted to scores out of 10. For the Course Interest Survey, the scores given are based on the arithmetic average of the scores on each of the five items in the survey. Also, where two pieces of data are entered at a particular grid position, one datum gives a survey form result and the other comes from interview; although not necessarily in this order, because some students were interviewed shortly before completing the survey form and others shortly afterwards. The order is not an issue since the average of the two data is used to determine trends.

Table 4.1
Biographical Details: Junior Girls

Dimension	Student				
	Angela	Henrietta	Kate	Rebecca	Zita
Status	Day student	Boarder	Day Student	Boarder	Boarder
Position in family	Sixth of ten	Fourth of five	Second of three	First of three	Second of five
Parents' occupations	Deputy Principal, home duties	Farmers/ graziers	Teachers	Farmers	Farmers
Age	Typical[a]	Typical	Typical	A few months older than typical	Typical
Entry to college	Year 8	Year 8	Year 8	Year 7	Year 8
Achievement	B→[b]C→B	B	C→D→E	B	B→D/C
Effort	2	2	2→3/4	2	1/2→3
Conduct and cooperation	1	1	2	1	1/2
Senior science subjects	Nil	Nil	N/A[c]	Biology	Biology

[a] That is, turned 13 years during Year 8. [b] Denotes a change through time. [c] Not applicable, as she repeated Year 10.

Table 4.2

Participation in Enrichment and Extracurricular Science Activities and Positions of Interviews: Junior Girls

Activity	Year	Student				
		Angela	Henrietta	Kate	Rebecca	Zita
Evening Science (Tom Kirkpatrick)[a]	8 (Term 2)		✓			
Australian Science Competition	8 (June)	✓	C[b]	✓	C	C
Science Contest Excursion	8 (Aug.)	✓	✓	✓		✓
Planetarium Excursion	8 (Aug.)	✓	✓	✓		✓
			Int 1[c]	Int 1		Int 1
Mine Excursion	9 (Term 2)	✓	✓	✓	✓	✓
Sciencentre Excursion	9 (Term 2)	✓	✓	✓	✓	✓
Australian Science Competition	9 (June)	✓	✓	✓	A	✓
Investigation	9 (Sem. 1)	A	A	D[d]		A
			Int 2	Int 2		Int 2
Evening Science (Gary Young)	10 (Term 2)		✓	✓		✓
Australian Science Competition	10 (June)	✓			D	✓
National Chemistry Quiz	10 (July)				D[e]	✓
Evening Science (Phil Webb)	10 (Term 3)					✓
Evening Science (Lyn Brodie)	10 (Term 4)		✓			✓
Primary Interface	10 (Sem. 2)	✓		✓	✓	✓
		Int 1	Int 3	Int 3	Int 1	Int 3

[a]Denotes an *Evening Science With a Guest* activity as opposed to *Evening Science*. [b]Where an award was received, the type of award is indicated. Awards in the Australian Science Competition were High Distinction (HD), Distinction (D), Credit (C), and Achievement (A). Criteria for awards in activities are given in Appendix 3.A. [c]Denotes first interview. [d]Awards in the Investigation were Distinction (D) and Achievement (A). [e]Awards in the National Chemistry Quiz were Excellence (HDEX), High Distinction (HD), Distinction (D), and Credit (C).

Table 4.3

Interest and Enjoyment in Being Involved in Science Activities: Junior Girls

Data technique	Student				
	Angela	Henrietta	Kate	Rebecca	Zita
Rating scale					
Yr. 8	8.0	9.0, 7.5	8.0, 7.5	9.0	4.0, 6.5
Yr. 9	7.0	8.0, 8.0	4.0, 6.5	8.0	3.0, 7.0
Yr. 10	7.5, 5.0	6.0, 8.0	4.0, 5.0	7.0, 8.0	5.0, 7.5
TOSRA (E) Enjoyment					
Yr. 8	7.6	5.0	8.8	7.6	4.6
Yr. 9	6.6	7.2	3.6	7.4	4.0
Yr. 10	5.0	5.6	4.2	7.4	5.4
TOSRA (L) Leisure					
Yr. 8	6.8	5.0	5.8	7.4	3.6
Yr. 9	4.6	4.8	2.8	7.0	3.8
Yr. 10	4.2	4.0	2.6	8.0	4.0
Course interest					
Yr. 8	6.6	7.2	8.8	8.0	4.8
Yr. 9	5.6	7.2	4.8	7.6	4.4
Yr. 10	4.8	6.0	4.4	6.8	4.4

Table 4.4
Motivation to Continue to Participate in Science: Junior Girls

Data technique	Student				
	Angela	Henrietta	Kate	Rebecca	Zita
Rating scale					
Yr. 8	8.0	6.0, 8.0	7.0, 9.5	9.0	4.0, 4.0
Yr. 9	7.0	8.0, 8.5	6.0, 5.0	8.5	4.0, 5.0
Yr. 10	7.0, 6.5	4.0, 1.0	5.0, 4.0	9.0, 7.0	7.0, 8.0
TOSRA (C) Career					
Yr. 8	5.8	4.2	7.8	6.4	3.6
Yr. 9	3.6	4.4	4.6	7.2	4.2
Yr. 10	4.2	5.0	3.8	7.8	5.0

Table 4.5
Perceptions About Scientists: Junior Girls

Data technique	Student				
	Angela	Henrietta	Kate	Rebecca	Zita
TOSRA (N) Normality					
Yr. 8	7.4	7.8	8.4	8.6	6.0
Yr. 9	7.6	7.4	6.0	9.0	6.4
Yr. 10	9.0	6.6	6.0	9.2	6.0

Table 4.6
Perceptions About the Role of Science in Society: Junior Girls

Data technique	Student				
	Angela	Henrietta	Kate	Rebecca	Zita
Rating scale					
Yr. 8	8.0	8.0, 9.0	9.0, 9.0	9.0	5.0, 8.0
Yr. 9	8.0	9.0, 8.5	6.0, 8.0	9.5	6.0, 5.5
Yr. 10	9.0, 8.5	10.0, 9.0	9.0, 8.0	9.0, 9.0	6.0, 6.5
TOSRA (S) Social					
Yr. 8	7.6	7.2	9.2	7.4	6.4
Yr. 9	7.6	7.6	6.0	8.2	6.0
Yr. 10	7.2	6.6	6.4	8.0	6.4

4.4 Case Studies: Junior Girls

Angela

Angela was a day student from a large family who entered Glendale College in Year 8. During the study period her achievement in science was B/C level and her effort and conduct and cooperation were both high. She was added to the sample group in Year 10 and so participated in only one interview. Angela participated in eight enrichment science activities but chose to participate in only one extracurricular activity, the Primary Interface. As indicated by the responses on her Extracurricular Science Activities survey forms, this was because the extracurricular science activities generally did not interest her.

Interest and enjoyment. Figure 4.1a shows Angela's graph of retrospective perceptions about her interest and enjoyment in being involved in science activities (an accurate reproduction of her hand drawing) and Table 4.3 contains further data pertaining to this variable. All data support the conclusion that Angela's interest and enjoyment decreased, from a high level, during her junior years. Angela said during

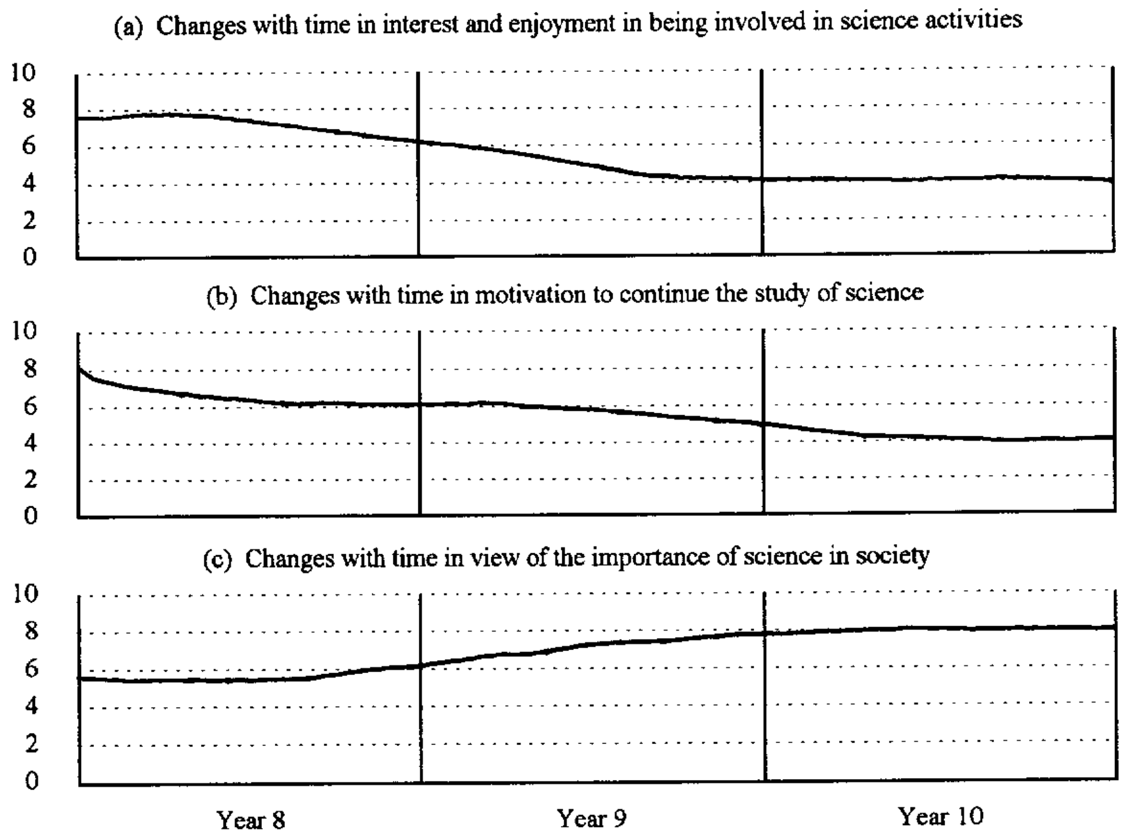

Figure 4.1. Graphs of retrospective trends: Angela.

interview that this decrease in her interest and enjoyment was due to finding the study of chemistry difficult during Years 9 and 10 and having no liking for the classwork topics during these years. However, in Year 10 she also said that she wanted to study biology the following year (although she didn't) because she found this area of science interesting. Participation in the Primary Interface had a small positive effect on her interest and enjoyment because she found her demonstration enjoyable and recognised from the expressions on the faces of the primary students that they also enjoyed it.

Motivation. Angela's motivation to continue to participate in science decreased, in accord with her interest and enjoyment, during her junior years (Figure 4.1b and Table 4.4). She said that during this time she had the desire to study biology in Year 11, but eventually chose no senior science subjects. Her career thoughts varied during these years but always revolved around the type of work undertaken by a recreation officer. As with her interest and enjoyment, the Primary Interface had a small positive effect on her motivation because "it's good to find new and interesting things by experiment."

Scientists. During her Year 10 interview Angela said that her perceptions about scientists were of people in a laboratory, doing research, usually always indoors, "pretty brainy," and of either sex and that she had fairly much the same view during Years 8 and 9. She said that no science activity in which she had participated influenced her view of scientists. Nothing she said during interview shed light on any reason for the increase in normality from a rating of 7.4 to 9.0 shown in the data of Table 4.5 and, because these data had not been collated at the time of interview, Angela was not asked directly about it.

Science in society. Angela's view of the importance of science in society increased slightly, to a high level, during her junior years (Figure 4.1c and Table 4.6). She confirmed this trend during her Year 10 interview when she firstly described her perception of the role of science in society as being to conduct further research in order that improvements can be made on the "things we have now" and contributed the increase to both exposure to newspapers and television and to her increased understanding of classwork concepts in her later junior years. In Year 8 she had felt that she "didn't really understand it [science] very much and didn't really care" but as her knowledge of science increased, she came to realise that science played a very important role in society.

Summary. A summary of the data for Angela is given in Table 4.7. In this table and the summary table for every other sample student, a positive effect for *interest and enjoyment* and *motivation* is one that had the effect of increasing the attitude described by the dependent variable and a negative effect decreased it. Note that a student may have found a particular activity interesting, for example, but that unless they also said that it also increased their interest and enjoyment in being involved in science activities in general (i.e. the dependent variable), the activity is not included in their summary table. Also, when recording contributions to positive effects on students' perceptions about the role of science in society in these summary tables, both effects that *broadened* perceptions of the role of science in society and those that *increased* the student's view of the importance of science in society have been included. Note that the former does not necessarily imply the latter.

Table 4.7
A Summary of the Data for Angela

		Contribution to variable		
Dependent variable	Overall trend	Positive effect	Negative effect	Longer-term effects
Interest and enjoyment	Decrease	Primary Interface	Classwork	
Motivation	Decrease	Primary Interface		
Perceptions about scientists	N/A[a]			
Role of science in society	Increase	Newspapers, television, classwork		

[a]Not applicable. Because students' perceptions about scientists can be broader than that measured by TOSRA Scale N (Normality of Scientists) alone, it is not appropriate to analyse this variable in terms of quantitative trends.

Henrietta

Henrietta was a boarder who came to the college in Year 8. She achieved in science at a B level and her effort and conduct and cooperation were both high. Henrietta participated in seven enrichment activities and three Evening Science With a Guest evenings, two of these in Year 10 in order to gain increased insight into career opportunities. Her reasons for not participating in other extracurricular activities were that she was not interested, preferred to be at home during vacation, or had higher priorities, like study.

Interest and enjoyment. Henrietta's interest and enjoyment in being involved in science activities increased, to a high level, during her junior years (Figure 4.2a). Contributing to her increase in interest and enjoyment during Year 8 were three factors. Firstly, her understanding of coursework improved as the year progressed. Henrietta said she came to the college without much background in science and her interest in science was low because she "didn't understand what was going on." The sharp increase in interest and enjoyment shown, towards the end of Year 8, in Figure

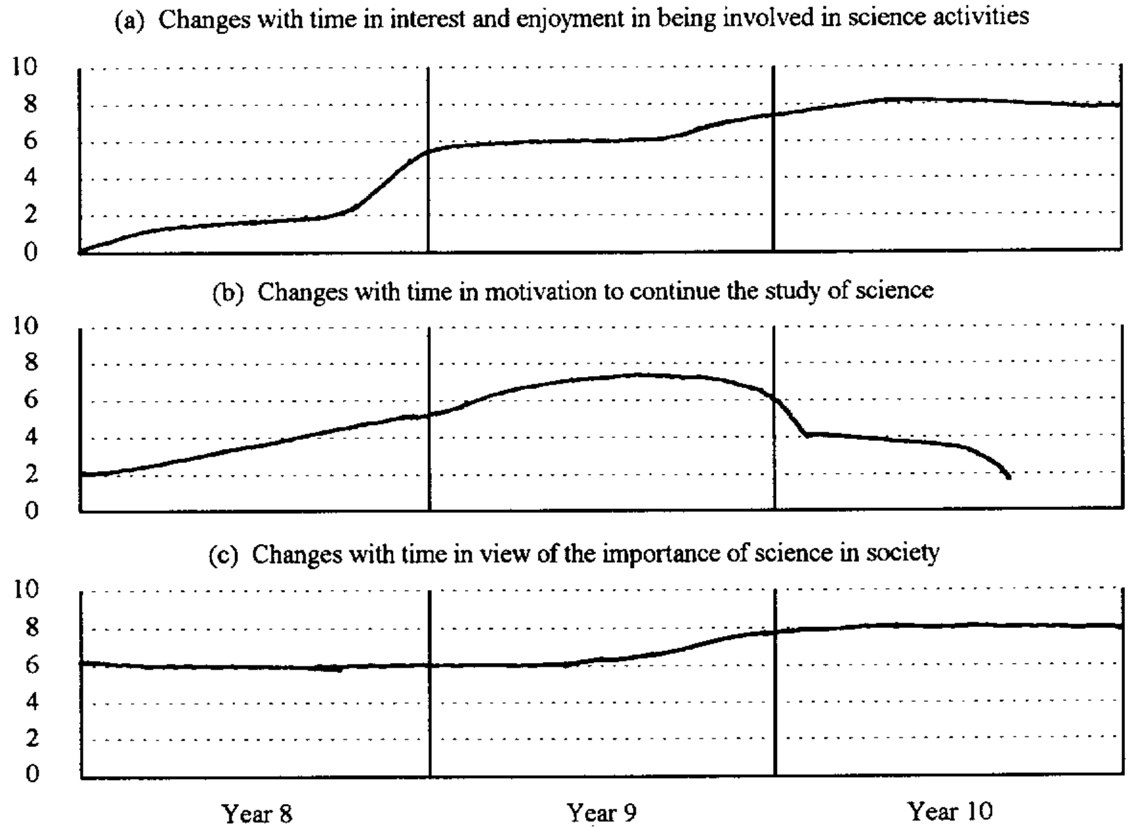

Figure 4.2. Graphs of retrospective trends: Henrietta.

4.2a was due to her, for the first time, "understanding what we were doing."

In addition, some content of the Australian Schools Science Competition in Year 8 had a relatively small effect on her interest and enjoyment by increasing her curiosity to find out more about such areas. The excursion to see the Queensland Science Contest entries, however, made a big impact in this area. It increased her interest and enjoyment because:

> it showed me that you don't have to be an absolute expert at science to know what you're doing . . . Even though I'm not a brain I can still learn a fair bit about science if I want to . . . It's made me want to see more about science.

Henrietta's interest and enjoyment during Year 9 increased as a result of a continued increase in understanding of coursework, her perception that the class practical work allowed more student autonomy than in Year 8, and the excursions to the mine and *Sciencentre*, with the latter of these two visits having the greater effect although she could not give a reason for the effect of either excursion. Tending to negate these positive contributions was her experience with the Year 9 Investigation. Henrietta tried to grow bean plants in various conditions of sunlight and moisture and, in addition to not having a clear understanding of what she was meant to be doing, found this activity very frustrating because she was a boarding student and other students would tamper with her equipment during term. She said vacation time was not appropriate for such work as she was not always in the same location.

During Year 10, her interest and enjoyment was buoyed a little by Evening Science with Lyn Brodie and by her reflections on the excursion to the Planetarium in Year 8 (despite not mentioning this activity in this context during her Year 8 interview). The effect of the former was a result of Lyn Brodie's encouragement of females to continue to participate in science and engineering, while she found the planetarium visit interesting and wouldn't mind "going into something like . . . looking at rocks which came down from the moon."

It is perhaps notable that Henrietta did not enter either the Australian Schools Science Competition or the National Chemistry Quiz during Year 10 when they were extracurricular as opposed to enrichment activities because she was in sick-bay on both occasions.

Motivation. The data of Figure 4.2b, together with Henrietta's interview comments, show that Henrietta's motivation to continue to participate in science during her junior years firstly increased and then decreased back to a low level. This final decrease is clearly supported by the dramatic change in Rating Scale score from an average of 7.0 to 2.5 in Table 4.4.

This variation in motivation was most closely related to how she perceived herself as coping with coursework. Towards the end of Year 8 Henrietta was thinking about choosing Biology and Chemistry in Year 11 with the longer-term view of entering either primary teaching or the police force. This was a time during which her understanding of coursework and interest and enjoyment in being involved in science activities were also increasing. Adding slightly to her motivation at this time was the experience of the Australian Schools Science Competition which she said gave little attention to chemistry and made her "realise that people need to know more about it [chemistry]" and this "makes me want to learn about it."

The Year 9 Investigation dampened her motivation a little for the same reasons as it had this same effect on her interest and enjoyment. However, during Year 10 she felt that she was struggling with the study of science (despite obtaining B grades for achievement) and her motivation decreased markedly as she came to the conclusion that "doing science next year wouldn't be a very bright idea." She consequently set her mind on a future in law, thinking that this field would be better suited to her abilities (she also did not consider herself highly skilled in practical work) than, for example, research in agronomy. Primary teaching and policing were her second and third preferences, respectively.

Scientists. From Year 8, when she said that "most people think of a scientist as an old guy with a grey beard, that sort of thing," Henrietta viewed a scientist as just a normal human being. She said during interview that this view of the normality of scientists remained fairly much unchanged during her junior years.

However, contact with guests Gary Young and Lyn Brodie during Year 10 strengthened her view. "With talking with Mr Young and Mrs Brodie, um, I realised that they're just normal people and they're just out there to try and help, not to make themselves look big." Prior to this she "thought they were a bit stuck-up . . . and thought that we owed them something." In relation to Evening Science with Gary Young, she also said:

> It showed me that, um, you don't have to be the most educated or intellectual person in the world to be involved [in science], anyone can be . . . People reckon that they're just a freak of nature sort of thing that's why they're so smart but they're not. They're just normal human beings who've got ambition.

Science in society. Figure 4.2c, together with Henrietta's interview remarks, indicate that her view of the importance of science in society increased steadily, to a high level, during her junior years. In Year 8 she gave the need for science to assist with Ethiopia's drought situation, ways of improving land, and coping with diseases in refugee populations as examples of why she considered science to have a fairly important role in society.

During Year 9 she experienced the deaths of persons close to her and her perceived need for scientists to find a cure for diseases increased her perception of the role of science in society. Her peers at school and others outside school also contributed to this effect by broadening her appreciation of the breadth of scientific endeavour.

She said that during Year 10, and in contrast with the corresponding flat section of the graph in Figure 4.2c, this perception was further increased by media exposure to medical breakthroughs and blood-typing activities in class.

Summary. Table 4.8 summarises the data for Henrietta. Note that because students' *perceptions about scientists* have not been judged to be positive or negative but simply recorded, any contributions to this variable have been placed, in students' summary tables, in the centre of the *Contribution to Variable* column.

Table 4.8
A Summary of the Data for Henrietta

		Contribution to variable		
Dependent variable	Overall trend	Positive effect	Negative effect	Longer-term effects
Interest and enjoyment	Increase	Increased understanding of coursework, Aust. Science Comp. (Yr. 8), Science Contest Excursion, Mine, *Sciencentre*, Planetarium, Lyn Brodie	Investigation	Planetarium
Motivation	Increase, then decrease	Understanding of coursework, Aust. Science Comp. (Yr. 8)	Investigation	
Perceptions about scientists		Gary Young, Lyn Brodie		
Role of science in society	Increase	Deaths of close persons, peers, persons outside school environment, media, classwork		

Kate

Kate came to the school as a day student in Year 8. Her science achievement dropped from a C to an E during her junior years and, while her conduct and cooperation was always high, her effort rating also decreased from a 2 to a 3/4 during this time. She participated in seven enrichment activities, Evening Science With a Guest on one occasion, and the Primary Interface; in the case of the latter, because "Angela needed a partner and I was sort of interested." None of the other extracurricular activities interested her.

Interest and enjoyment. Kate's interest and enjoyment in being involved in science activities decreased during the study period (Table 4.3 and Figure 4.3a). The initial increase at the beginning of Year 8 shown in Figure 4.3a was due to the novelty of the course. "I really enjoyed it because you know like you'd never done that kind of stuff before in primary school." During second semester, Year 8, both the Science Contest and Planetarium Excursions had positive effects on her interest and enjoyment, but the downward trend shown in Figure 4.3a reflected the fact that these effects were swamped by the effect on her of finding the coursework "a bit hard." With regard to the science contest entries she said: "When we went to see all the entries it was really amazing like what you could do yourself, all the entries were really good and gave me a few ideas what I could do next year." The Dome Show at the Planetarium had an even greater effect. She found it interesting and it encouraged her to look at the stars afterwards at home. It "made me more keen to learn things about our Solar System and all sorts of things like that."

Continuing to decrease her interest and enjoyment in Year 9 were her dislike of the topics covered and the fact that many classes were conducted in a hot, poorly equipped room which also doubled as a weight-training gymnasium. However, two activities had relatively small positive effects on her interest and enjoyment; the *Sciencentre* Excursion which left her with a desire to visit again, despite having been there on three previous occasions, and her investigation. Kate grew and classified different types of herbs, the stimulus for which came from the previous year's Science Contest Excursion. She said she enjoyed the activity and it also allowed her to acquire a more extensive knowledge of herbs. At the end of Year 9 she couldn't really remember the planetarium visit which had made a significant impact the previous year.

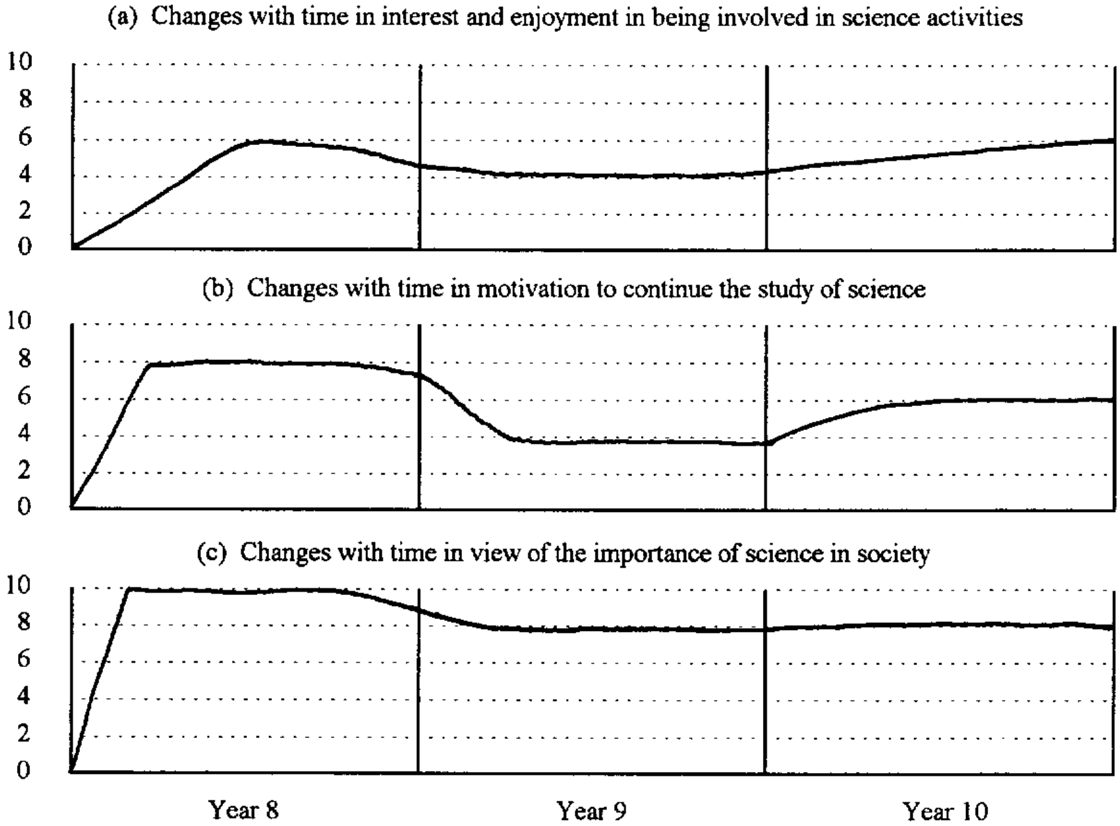

Figure 4.3. Graphs of retrospective trends: Kate.

During interview Kate said her interest and enjoyment in being involved in science activities increased a little from Year 9 to Year 10 (in accord with Figure 4.3a) because she regarded the classwork topics to be more interesting than in Year 9.

Motivation. Kate's motivation to continue to participate in science decreased during the study period (Table 4.4 and Figure 4.3b). During interview she said that her level of motivation varied in accord with her perceived interest and enjoyment, confirmed by a comparison of Figures 4.3a and 4.3b. Kate also said her motivation increased from Year 9 to Year 10 because she had a greater liking for the classwork topics in the latter year.

During Year 8, the Australian Schools Science Competition had a small positive effect on her motivation because "some of the questions were really interesting and made me want to do more about it."

During Year 9, Kate thought she would study biology in her senior years, although she had no career thoughts. Despite the overall decrease in her motivation from Year 8 to Year 9, she said there were three positive influences on her motivation during Year 9. She found the experience with novel phenomena at the *Sciencentre* interesting. Her investigation involving the growing and classification of a variety of herbs was not only enjoyable, because she said she enjoyed working with plants and animals, but also led her to think that senior biology could be an option. The certificate she received for work of a high standard further supported this possible senior subject choice because she felt that since she obtained a fairly good result here she could perhaps do well in biology. Third, Kate's liking for biology came through strongly in interview when she said that, contrary to the trends shown in Figure 4.3b and Table 4.4, her motivation to continue to participate in science actually increased a lot between Year 8 and Year 9 as a result of the biology topics in the Year 9 classwork topics which dealt primarily with the human body.

During Year 10 Kate had begun to focus on a career in travel and hotel management. She thought her liking for biology topics would probably see her choose senior biology. Although the trends in Kate's achievement grades and effort ratings in other subjects did not all mirror the decline shown in Table 4.1 for science, Kate subsequently repeated Year 10 at another school.

Scientists. During Year 8, Kate thought of scientists as people who do many experiments, try to find cures for diseases or problems, and sometimes teach. She thought they made an important contribution to society, and this view of scientists did not change during her junior years.

Both the planetarium visit in Year 8 and Evening Science with Gary Young in Year 10 broadened her view of the work of scientists. In the case of the former she said she "didn't know that they [scientists] did things with the stars. I thought they were a totally different thing."

Her experience at the *Sciencentre* led her to believe that the work of scientists can be quite interesting and not as boring as she had previously thought, although this change in perception is perhaps at odds with the decrease in her view of the normality of scientists between Year 8 and 9 shown in Table 4.5.

Science in society. Kate's perception of the importance of science in society effectively decreased during the study period, although it was consistently high (Table 4.6 and Figure 4.3c). At the end of Year 8 she rated the contribution of science to society relatively highly, saying that without science society would not have the knowledge which it currently enjoys. This rating dropped in Year 9 as a result of her not liking science much during that time and it did not increase afterwards. However, she said that Evening Science with Gary Young during Year 10 did broaden her view of the contribution of science to society.

Summary. A summary of the data for Kate is given in Table 4.9.

Table 4.9
A Summary of the Data for Kate

		Contribution to variable		
Dependent variable	Overall trend	Positive effect	Negative effect	Longer-term effects
Interest and enjoyment	Decrease	Novelty of classwork, Science Contest Excursion, Planetarium, *Sciencentre*, Investigation, coursework topics	Coursework difficulty & topics, uncomfortable classroom	
Motivation	Decrease	Aust. Science Comp. (Yr. 8), *Sciencentre*, Investigation, classwork topics		
Perceptions about scientists		Planetarium, Gary Young, *Sciencentre*		
Role of science in society	Decrease	Gary Young	Dislike of science	

Rebecca

Rebecca came to the college as a boarder in Year 7. Her achievement in science was at a B level throughout Years 8, 9, and 10, both her effort and conduct and cooperation were high, and she was also added to the junior sample in Year 10. Rebecca participated in five enrichment activities and volunteered, in Year 10, for both the National Chemistry Quiz (because she wanted to see how she would achieve relative to students outside Glendale College) and the Primary Interface. During Year

10 she achieved particularly well in obtaining a Distinction in both the Australian Schools Science Competition and the National Chemistry Quiz. She did not participate in other extracurricular activities because they either did not interest her or she had higher priorities such as homework.

Interest and enjoyment. Rebecca's interest and enjoyment in being involved in science activities was relatively high and fluctuated during her junior years but, in an overall sense, did not change (Figure 4.4a).

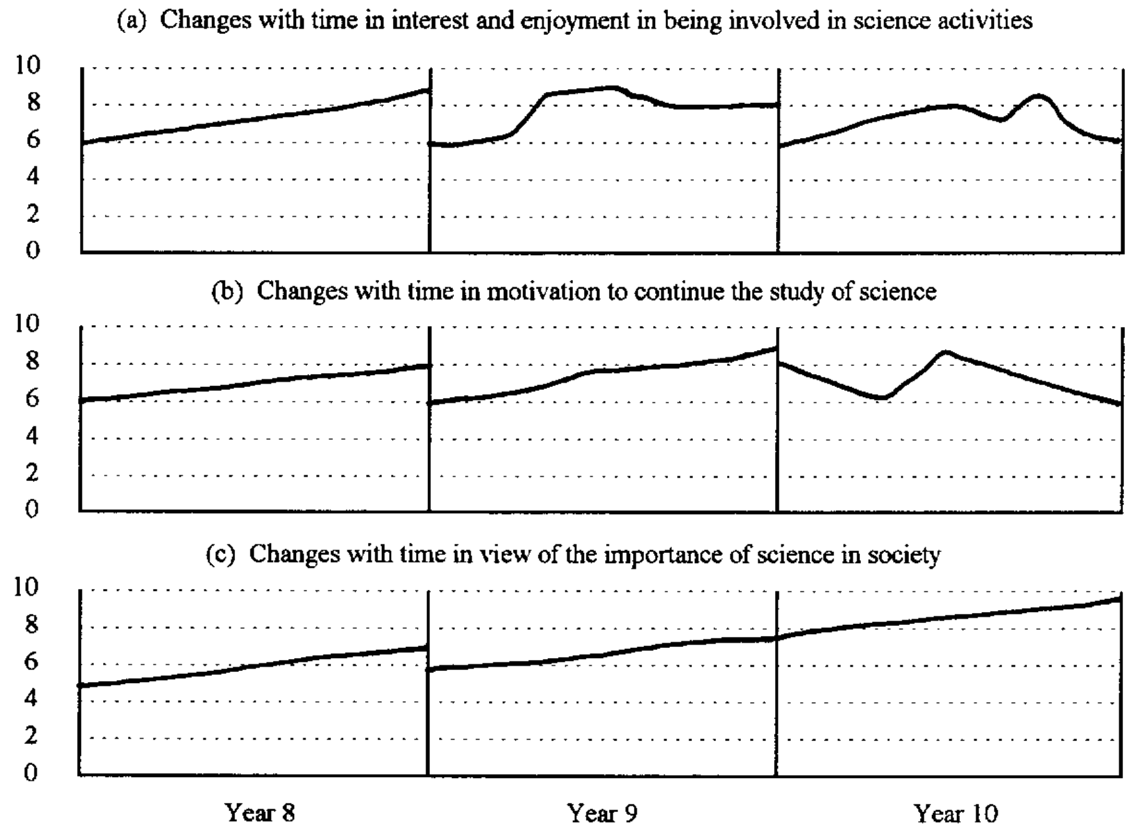

Figure 4.4. Graphs of retrospective trends: Rebecca.

She said that most of the variation shown in Figure 4.4a could be attributed to her interest in, and ability to cope with the demands of, coursework topics. This specifically applied to the beginning of Years 9 and 10 when she found the classwork difficult. The exception is the last peak shown in the figure which was a result of her involvement in the Primary Interface because she "enjoyed it and sort of helped others to learn about it," thus giving her a sense of achievement.

Also having a positive effect in Year 10 were the Australian Schools Science

Competition and the National Chemistry Quiz. The distinction she obtained in the former caused her to think that she must know something about science and she therefore must be enjoying it because she's remembering it. Prior to doing the National Chemistry Quiz Rebecca said that she was planning to study chemistry in her senior years and that this competition increased her interest and enjoyment because she didn't find the test too difficult.

The visit to the *Sciencentre* in Year 9 was having a lasting effect, in Year 10, on both her interest and enjoyment and her motivation to continue to participate in science because "as I enjoyed it it sort of pushed me on to do something like that."

Motivation. Rebecca's motivation to continue to participate in science remained relatively high and constant during her junior years (Figure 4.4b), although her career interest in science did increase significantly during this time (Table 4.4). She said the variations in motivation shown in Figure 4.4b were, as with her interest and enjoyment, reflections of her level of interest in, and the degree of difficulty of, coursework topics.

During Years 8 and 9 Rebecca had a career in veterinary science in mind, but during Year 10 she thought that this may not suit her totally and narrowed her focus to future work with cattle and horses, although she was not sure exactly how she would achieve this. She also found the chemistry and physics coursework in Year 10 difficult and this experience suggested to her that she might study biology only during her senior years, although she thought chemistry was still a possibility.

The activities which increased her interest and enjoyment during Year 10 also increased her motivation to continue to participate in science. She said her high achievement (a Distinction) in the Australian Schools Science Competition motivated her to do better and to get more involved in science and her Distinction in the National Chemistry Quiz had a similar effect because she thought "well if I can do good at this I should maybe keep on doing it and do better." Rebecca said that because she enjoyed the Primary Interface she could probably see herself doing something in science at a later stage, and the longer-term effect of the visit to the *Sciencentre* has been mentioned previously.

Scientists. During her Year 10 interview (her only interview) Rebecca said that her view of scientists was of people who discover further information about diseases or living things and try to improve, or create new, methods. She thought either sex could participate in science, either indoors or outdoors, and, as shown in Table 4.5, rated the normality of scientists very highly. She also said that as she had grown older, continuing exposure to books and television and continued participation in science classes had broadened her knowledge of the work of scientists and this had increased her respect for them.

Rebecca said that participation in the Primary Interface gave her a better idea of the role of scientists in conducting experiments and communicating the results to others.

Science in society. Rebecca's rating of the social implications of science increased, to a very high level, during her junior years (Figure 4.4c). During her Year 10 interview she explained this relatively high perception in terms of the contribution science has made to curing diseases and increasing our understanding "about the way people live and how the animal and machine worlds work." While feeling that the work of scientists is generally for the better, she also remarked that "sometimes they do come across the things that probably should've been left alone."

Rebecca said that the increase in her perception of the role of science in society during her junior years was the result of continued accumulation of knowledge pertaining to the contribution science has, and is, making. This knowledge came from classwork, excursions (she could not be specific), and the Primary Interface. For the latter she prepared and carried out a series of liquid nitrogen demonstrations which, because she could see the everyday applications, increased her perception of the contribution of science to society.

Summary. Table 4.10 summarises the data for Rebecca.

Zita

Zita was a boarding student who entered the college in Year 8. While her conduct and cooperation were high during her junior years, her achievement decreased from B to D/C level and her effort rating dropped from 1/2 to 3. Zita participated in seven enrichment activities. Although she was not sufficiently interested, or didn't rate the activities a sufficiently high priority, to volunteer for any extracurricular activities during Years 8 or 9, she was sufficiently interested to enrol

Table 4.10
A Summary of the Data for Rebecca

Dependent variable	Overall trend	Contribution to variable: Positive effect	Contribution to variable: Negative effect	Longer-term effects
Interest and enjoyment	No overall change	Coursework, Primary Interface, Aust. Science Comp. (Yr. 10), Nat. Chem. Quiz, *Sciencentre*	Coursework	*Sciencentre*
Motivation	No overall change	Coursework, Aust. Science Comp. (Yr. 10), Nat. Chem. Quiz, Primary Interface, *Sciencentre*	Coursework	*Sciencentre*
Perceptions about scientists		Books, television, coursework, Primary Interface		
Role of science in society	Increase	Coursework, excursions, Primary interface		

in six extracurricular activities during Year 10.

Interest and enjoyment. As supported by Figure 4.5a and the Rating Scale score increase from 4.0 to 7.5 shown in Table 4.3, Zita said during interviews that her interest and enjoyment in being involved in science activities increased, to a high level, during her junior years. At the beginning of Year 8 she said she found science boring and "not worth it." However, as Year 8 progressed she "began to like it a bit more" and two activities contributed positively to her interest and enjoyment. She said that obtaining a credit in the Australian Schools Science Competition "sort of, made [me] more positive about science." She also found perusal of the Queensland Science Contest entries (during the Science Contest Excursion) interesting. "I liked to see how they worked and how people made them . . . It shows that science can be fun."

Zita found classwork more interesting during Year 9. In particular, she thought she did more experimental work that year than the previous year and said: "I'd rather

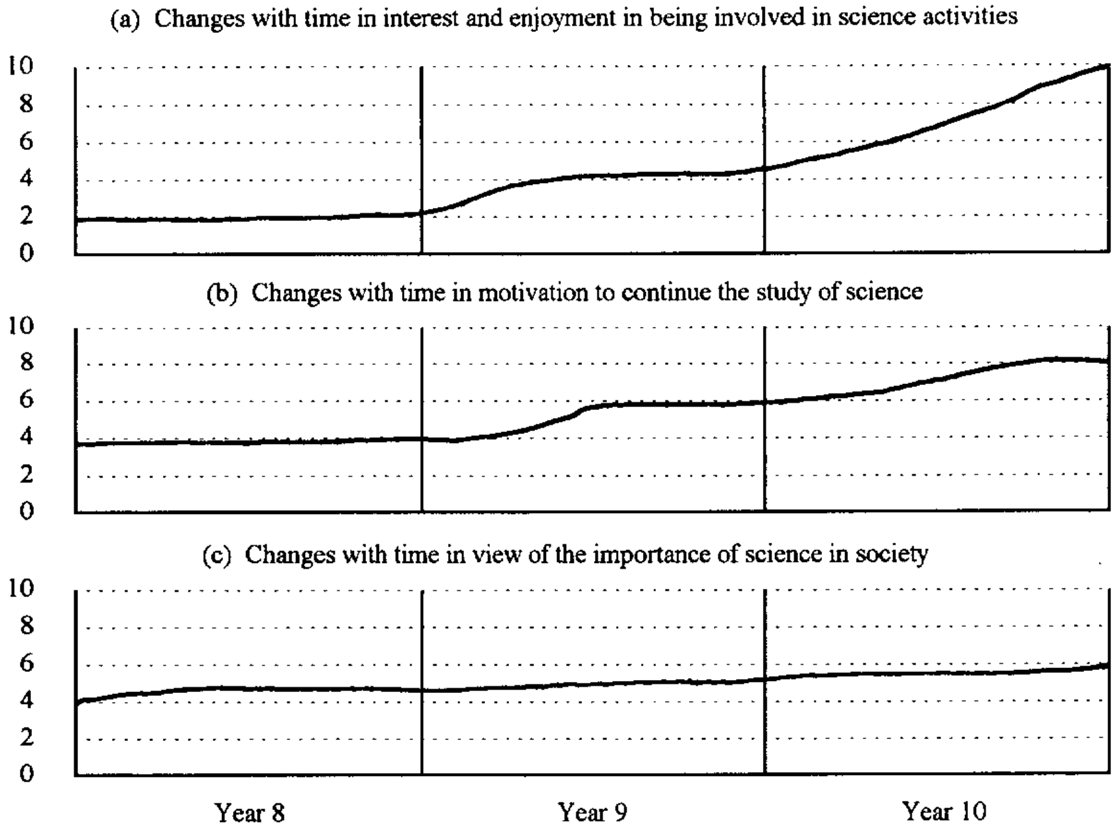

Figure 4.5. Graphs of retrospective tends: Zita.

. . . find out for myself something rather than having the teacher just stand up there and tell us." In addition to this, two Year 9 activities again made a positive impact on her interest and enjoyment. For her investigation she chose to study the effect of different kinds of food on the weight and behaviour of guinea pigs. She found this a novel experience because, in contrast to routine classwork experiments, it provided students with the opportunity to investigate questions of their choice using a procedure which is not teacher-imposed. However, the visit to the *Sciencentre* made the biggest impact during Year 9, despite the fact that she had visited on one previous occasion when the exhibits were housed in an earlier building. She found that the exhibits had been enhanced in both number and variety and, as previously noted in relation to classroom experimental work, responded positively to the hands-on nature of the activities. "I'd rather see things and do things like I said before."

Further enhancing Zita's interest and enjoyment in being involved in science activities during Year 10 were her participation in the Primary Interface, Evening

Science With Guests (although she could not identify any specific evenings), and classwork which she said had become more interesting.

Motivation. Zita's motivation to continue to participate in science increased during her junior years (Figure 4.5b and Table 4.4), and this increase was related directly to her degree of certainty about her career goal.

During Year 8 Zita thought that she would probably need to study a science subject in senior, although she had no career plans. During Year 9 she thought that she might train to be a registered nurse and, because it meant she would need to study senior biology, this increased her motivation. During Year 10, having decided more definitely that nursing was the future direction she wished to take and having made the appropriate subject choice (including Biology as her only senior science), Zita said her motivation increased markedly because she realised that science would be a part of the pathway to this career.

Prior to doing the National Chemistry Quiz in Year 10, she said she was thinking about studying senior chemistry but "when the results came back and I didn't really do too well I sort of realised that chemistry wasn't sort of the subject for me."

Scientists. Zita's Year 8 view of a scientist was of someone involved with experimenting and inventing and she said that either sex could participate. In Year 10 she said this earlier view had not changed and that she had "always thought they [scientists] were just normal everyday people."

Five activities affected her view of scientists or the nature of their work. During Year 8, exposure to entries in the Queensland Science Contest (during the Science Contest Excursion) led her to believe "that they [scientists] can make things quite easily without using all the technology which we have." During Year 9, the Investigation made her "realise that their [scientists] work wasn't just all hard work, that sometimes they might do have fun while they're still doing their work, experimenting" and the nature of the exhibits at the *Sciencentre* left her with the impression that scientists must be "pretty brainy." In Year 10, Evening Science with Phil Webb broadened her perception of the type of work performed by scientists and Evening Science with Lyn Brodie reinforced the fact that women can do engineering.

Science in society. During her Year 8 interview Zita said that science made an important contribution to society because it strived to make the world a better place, giving as an example the use of technology to make life easier. During each of her Year 9 and Year 10 interviews she said she did not perceive any change to her view of the importance of science in society compared with the previous year.

However, during reflection towards the end of Year 10 (Figure 4.5c) she said that her view had increased slightly after Year 8 "as she got older and started thinking about it more" and also as a result of the broadening effect Evening Science with Gary Young had on her view of the role of science in society.

Summary. A summary of the data for Zita is given in Table 4.11.

Table 4.11
A Summary of the Data for Zita

		Contribution to variable		
Dependent variable	Overall trend	Positive effect	Negative effect	Longer-term effects
Interest and enjoyment	Increase	Classwork, Aust. Science Comp. (Yr. 8), Sc. Contest Ex., Investigation, *Sciencentre*, Primary Interface, Evening Science (with guests)		
Motivation	Increase	Career goal	Nat. Chem. Quiz	
Perceptions about scientists		Sc. Contest Ex., Investigation, *Sciencentre*, Phil Web, Lyn Brodie		
Role of science in society	Small increase	Gary Young, thought about it more as she got older		

4.5 Background Information: Junior Boys

Biographical Details

Table 4.12 summarises the biographical details of the junior sample boys.

Participation in Activities

Table 4.13 summarises participation, in chronological order where appropriate, by junior sample boys in the enrichment and extracurricular science activities. Only those activities experienced by sample students are listed and so they do not include all activities offered.

4.6 Some Quantitative Data: Junior Boys

Tables 4.14 to 4.17 report the quantitative data from each survey instrument administered, plus the *Rating Scales* completed during interviews where applicable, for each dependent variable.

Table 4.12
Biographical Details: Junior Boys

Dimension	Student				
	Hugh	Jeff	Richard	Talbot	Warwick
Status	Boarder	Boarder	Boarder	Boarder	Boarder
Position in family	Second of three	Second of four	Second of two	First of three	First of two
Parents' occupations	Farmers	Computer systems analyst, home duties	Graziers	Graziers	Pastoral managers
Age	A few months older than typical	A few months younger than typical	Typical	Typical	Typical
Entry to college	Year 8	Year 8	Year 8	Year 8	Year 8
Achievement	A/B	A	A/B	Typically B (C in Yr. 9)	A/B
Effort	1/2	2	1/2	2/3	2 (but 4 for Sem. 1, Yr. 9)
Conduct and cooperation	Typically 1 (but 3 during Yr. 9)	2	1	1/2, 3 during Year 9	2
Senior science subjects	Chemistry, Physics	Nil	Physics	Chemistry, Physics	Biology, Chemistry

Table 4.13
Participation in Enrichment and Extracurricular Science Activities and Positions of Interviews: Junior Boys

Activity	Year	Student				
		Hugh	Jeff	Richard	Talbot	Warwick
Evening Science (Peter Walsh)[a]	8 (Term 1)		✓			
Evening Science (Tom Kirkpatrick)	8 (Term 2)		✓			✓
Australian Science Competition	8 (June)	✓	C[b]	✓	✓	D
Evening Science (Stephen Sexton)	8 (Term 3)		✓		✓	
Science Contest Excursion	8 (Aug.)	✓	✓	✓	✓	✓
Planetarium Excursion	8 (Aug.)	✓	✓	✓	✓	✓
Evening Science (Bob Henzell)	8 (Term 4)	✓	✓		✓	
Hermitage	8	✓				✓
Evening Science	8	3[c] Int 1[d]	5 Int 1	2 Int 1	5 Int 1	1 Int 1
Mine Excursion	9 (Term 2)	✓	✓	✓	✓	✓
Sciencentre Excursion	9 (Term 2)	✓	✓	✓	✓	✓
Australian Science Competition	9 (June)	D	D	A	C	✓
Investigation	9 (Sem. 1)	D	D	A	A	A
Evening Science	9	3 Int 2	6 Int 2	7 Int 2	5 Int 2	Int 2
Evening Science (Gary Young)	10 (Term 2)	✓	✓			
Australian Science Competition	10 (June)	C	D	D	D	✓
National Chemistry Quiz	10 (July)	D	HD	D	D	✓
USQ Seminar	10 (Aug.)		✓	✓	✓	
Evening Science (Phil Webb)	10 (Term 3)		✓	✓		✓
Evening Science (Lyn Brodie)	10 (Term 4)	✓	✓			✓

Table 4.13 (con't)

Activity	Year	Student				
		Hugh	Jeff	Richard	Talbot	Warwick
Primary Interface	10 (Sem. 2)	✓	✓			✓
Evening Science	10		7	2	7	
Science Club	10		7	2	7	⅔ yr
	10	Int 3	Int 3	Int 3	Int 3	Int 3

[a]An *Evening Science With a Guest* activity. [b]Where an award was received, the type of award is indicated. An explanation of the significance of each award is given with the description of the activity in Appendix 3.A. [c]Indicates number of attendances during the year. [d]Denotes first interview.

Table 4.14
Interest and Enjoyment in Being Involved in Science Activities: Junior Boys

Data technique	Student				
	Hugh	Jeff	Richard	Talbot	Warwick
Rating scale					
Yr. 8	6.0, 7.0	9.0, 9.5	6.0, 7.0	9.0, 8.0	8.0, 8.5
Yr. 9	8.0, 8.0	7.0, 8.0	5.0, 4.5	8.0, 7.5	8.0, 7.0
Yr. 10	9.0, 8.0	5.0, 6.0	7.0, 6.0	7.5, 7.0	7.0, 7.0
TOSRA (E) Enjoyment					
Yr. 8	9.0	8.0	7.8	6.8	9.4
Yr. 9	5.6	6.6	4.8	6.4	7.4
Yr. 10	7.2	5.0	6.2	6.4	7.6
TOSRA (L) Leisure					
Yr. 8	8.2	7.6	5.8	5.8	6.6
Yr. 9	6.8	6.0	5.6	3.4	4.6
Yr. 10	6.8	5.0	5.0	3.2	6.0
Course interest					
Yr. 8	5.6	4.2	5.6	8.0	8.8
Yr. 9	5.2	4.0	5.4	7.6	7.6
Yr. 10	6.8	4.4	5.8	7.2	6.8

Table 4.15
Motivation to Continue to Participate in Science: Junior Boys

Data technique	Student				
	Hugh	Jeff	Richard	Talbot	Warwick
Rating scale					
Yr. 8	2.0, 8.0	7.5, 6.0	6.0, 6.0	4.0, 7.0	10.0, 10.0
Yr. 9	5.0, 6.0	6.0, 6.0	3.0, 4.5	6.0, 5.5	8.0, 10.0
Yr. 10	7.0, 5.0	1.0, 3.0	6.5, 7.0	6.5, 9.0	9.0, 6.0
TOSRA (C) Career					
Yr. 8	8.2	6.8	6.0	5.0	5.2
Yr. 9	6.2	5.6	6.2	4.0	5.4
Yr. 10	5.8	4.4	6.0	4.2	5.6

Table 4.16
Perceptions About Scientists: Junior Boys

Data technique	Student				
	Hugh	Jeff	Richard	Talbot	Warwick
TOSRA (N) Normality					
Yr. 8	7.0	7.8	6.2	6.6	8.0
Yr. 9	6.0	6.0	6.0	6.0	6.8
Yr. 10	7.0	6.6	6.2	5.2	6.8

Table 4.17
Perceptions About the Role of Science in Society: Junior Boys

Data technique	Student				
	Hugh	Jeff	Richard	Talbot	Warwick
Rating scale					
Yr. 8	6.0, 10.0	9.0, 9.0	8.0, 9.0	7.0, 8.0	9.0, 7.0
Yr. 9	10.0, 10.0	8.0, 9.0	6.5, 6.0	8.0, 7.5	6.0, 5.0
Yr. 10	9.0, 7.5	6.0, 7.5	8.0, 8.5	6.5, 7.5	6.0, 6.5
TOSRA (S) Social					
Yr. 8	8.8	8.4	8.0	7.2	6.6
Yr. 9	7.6	6.0	6.8	5.8	5.8
Yr. 10	7.4	6.0	6.4	6.4	6.4

4.7 Case Studies: Junior Boys

Hugh

Hugh came to Glendale College as a boarder in Year 8. His science achievement during Years 8, 9, and 10 was at A/B level and his effort and conduct and cooperation were generally high, the exception being a slightly lower C (satisfactory) report for conduct and cooperation during Year 9. Hugh participated in seven enrichment activities and seven extracurricular activities, as well as attending Evening Science on six occasions during Years 8 and 9 only following the recommendation of another student.

Interest and enjoyment. Hugh's interest and enjoyment in being involved in science activities increased, to a very high level, during his junior years (Figure 4.6a). He said that during Year 8 his interest and enjoyment in being involved in science activities progressively increased as he settled in to the secondary school environment and "got more out of classes," and that participation in each of the following activities also made a positive contribution for the reasons given in parentheses: the Australian Schools Science Competition (because it "contained things that I do, like as a person,

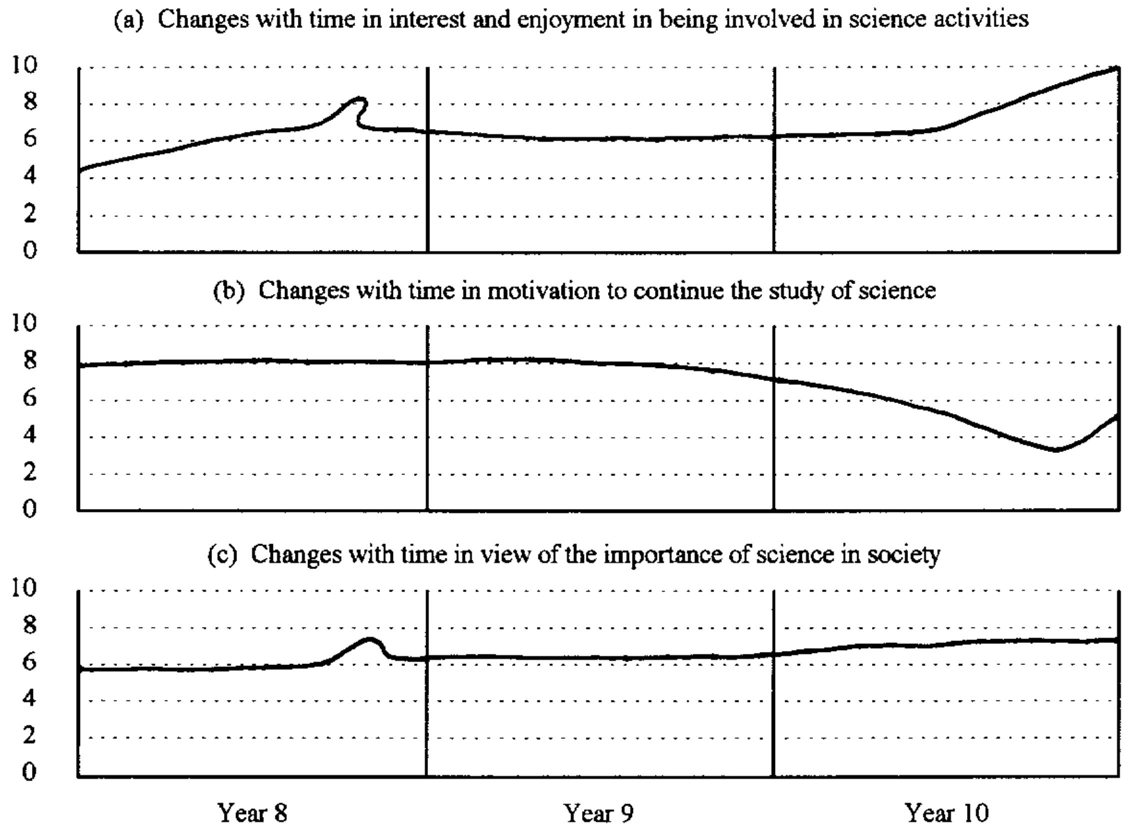

Figure 4.6. Graphs of retrospective trends: Hugh.

just common interests"), the Science Contest and Planetarium excursions (some displays interesting), Evening Science (hands-on nature of the activity), and the Bob Henzell Evening (topics interesting). He said that this last activity made the greatest positive impact (reflected in the peak shown in Figure 4.6a), leading him to choose the cross-breeding of sorghum as the topic of his Year 9 Investigation.

Making positive contributions to his interest and enjoyment during Year 9 were Evening Science (allowed him to extend classwork experiments by changing further variables), the Mine excursion (interesting), the *Sciencentre* Excursion (interesting, could find things out for himself), and his Investigation involving the cross-breeding of sorghum (enjoyed doing it). At the same time, he contributed the slight dip shown in Figure 4.6a to work on his investigation becoming tedious and obtaining results which were not as good as he expected. This was a very short-term effect.

During Year 10, participation in the National Chemistry Quiz (getting a distinction), the Gary Young Evening (enjoyed it), and, to a much greater extent, the

Primary Interface (he enjoyed it, "especially when it worked in front of students") all contributed positively, with the latter being primarily responsible for the upward trend shown in Figure 4.6a towards the end of Year 10.

Hugh said that, after experiencing the effect of doing his first Australian Schools Science Competition, subsequent competitions did not affect him significantly. He also said that the Bob Henzell Evening and Year 9 Investigation were having longer-term positive effects on his interest and enjoyment because, when related topics such as genetics were being dealt with in class, they "meant more to him then" and at such times his interest and enjoyment increased.

Motivation. Hugh's interview comments about his change in motivation to continue to participate in science during his junior years contradict the decline shown, in Figure 4.6b, from Year 9 to 10. There appears to have been no significant overall change in this variable.

The following activities contributed to Hugh's high motivation, during Year 8, to continue to participate in science; the Science Contest excursion (because some exhibits such as the solar irrigation system related to work that his father was doing at home), the Planetarium Excursion (because it increased his interest), Evening Science (it gave him an opportunity to focus on some areas, such as chemical reactions, which he likes), and the Bob Henzell Evening and Hermitage visit (because he found them interesting).

Towards the end of Year 9 Hugh was leaning towards a career in the business area; he mentioned business analyst and stockbroker as possibilities. During this year the Australian Schools Science Competition had the effect of steering him away from the future study of biology (because he found chemistry and physics easier to understand) but, contrary to the trend shown in Figure 4.6b, Hugh said at the end of the year that his motivation to study Chemistry and Physics in Year 11 had increased markedly because he enjoyed these areas. He said that Evening Science, by providing an opportunity to do chemical experiments, motivated him to study Senior Chemistry.

During Year 10, both the National Chemistry Quiz (because receiving a Distinction made him think that he could do fairly well in the sciences) and the Lyn Brodie Evening (because it exposed him to fields of engineering of which he was previously unaware) motivated him to continue to participate in science. However, at the end of the year he still had his mind set on a future in the business area and had decided that he would study Accounting and Economics in Year 11. At the same time, timetabling permitting, he said he would also like to study Chemistry and Physics as this would keep his future options open. Contrary to the trend shown in Figure 4.6b, he said that this was also the reason for his motivation to continue science increasing from Year 9 to Year 10. The timetable for proposed school subjects did not make it possible for Hugh to continue both these science and business subjects. However, subsequent to the data-collection phase of this study, the timetable was varied and Hugh ended up studying both Senior Chemistry and Physics.

Scientists

Hugh's Year 8 perception of a scientist as a "normal person with a normal job . . . job nothing special . . . a job they get into and like . . . normal working people" remained unchanged during his junior years and was reinforced by participation in both the Bob Henzell evening (and by subsequently playing cricket against this scientist) and the Primary Interface because, throughout the latter activity, he saw himself acting like a scientist and he considered himself an "everyday person."

The following activities all broadened his perception of the type of work in which scientists are engaged: the Australian Schools Science Competition, Planetarium visit, Mine excursion (especially the role of environmentalists), Investigation, and the Lyn Brodie and Gary Young Evenings. The latter also changed his perception of a scientist who focuses on a single project for most of their lives to a person who can be involved in a variety of projects.

Science in Society

Hugh's view of the importance of science in society increased slightly during his junior years (Figure 4.6c and his interview comments). In Year 8 Hugh viewed the role of science in society in terms of providing cures for diseases, saying: "I suppose society wouldn't be here without a lot of scientific breakthroughs." This view remained unchanged, during his junior years, with his increase in frequency of watching the news (and seeing medical breakthroughs) during Year 9 increasing his view of the importance of science in society. He said his perceived lack of such media coverage during Year 10 led to a decrease in his view of the importance of science in society.

The following activities all broadened Hugh's perception of the role of science and, by so doing, many also increased his view of the importance of science in society: The Australian Schools Science Competition, Year 8 ("Didn't kind of realise how you could call some of the stuff in here [the competition items] scientific."), Planetarium excursion, Bob Henzell Evening (because of how sorghum cross-breeding research was being used to help Third-World countries to grow food in their environment), Mine excursion, and the Lyn Brodie and Gary Young Evenings.

Summary. Table 4.18 summarises the data for Hugh.

Jeff

Jeff entered the college as a boarder in Year 8. He was an A-level achieving student with high effort and conduct and cooperation ratings. In addition to participating in seven enrichment and 11 extracurricular activities, Jeff attended Evening Science on 18 occasions. He obtained a High Distinction in the National Chemistry Quiz in Year 10.

Interest and enjoyment. Jeff's interest and enjoyment in being involved in science activities decreased during his junior years (Table 4.14 and Figure 4.7a). However, contrary to Figure 4.7a, Jeff said, during interview, that his interest and enjoyment increased between mid-Year 8 and end-Year 9.

The increase in interest and enjoyment shown in Figure 4.7a at the beginning of Year 8 reflected the novelty of components of the science course. Jeff regarded his primary science background as very basic and first-time exposure to student experiments and apparatus like bunsen burners increased his interest in science. During the remainder of Year 8, four science activities made positive contributions.

While doing the Australian Schools Science Competition which "probably made me think how interesting science was," Jeff was determined that he would try to obtain a higher award the following year. Despite having seen the Planetarium show during a school excursion the previous year, the Year 8 show encouraged him to look at the stars that night and motivated him to visit the Planetarium again during the coming vacation. However, Evening Science and the Science Contest Excursion made

Table 4.18
A Summary of the Data for Hugh

Dependent variable	Overall trend	Contribution to variable		Longer-term effects
		Positive effect	Negative effect	
Interest and enjoyment	Increase	Aust. Science Comp. (Yr. 8), Science Contest Excursion, Planetarium, Evening Science (Yr. 8, 9), Bob Henzell, Mine, *Sciencentre*, Investigation, Nat. Chem. Quiz, Gary Young, Primary Interface		Bob Henzell, Investigation
Motivation	Contradictory (no change)	Science Contest Excursion, Planetarium, Evening Science (Yr. 8, 9), Bob Henzell, coursework, Hermitage, Nat. Chem. Quiz, Lyn Brodie	Aust. Science Comp. (Yr 9, Biol. only)	
Perceptions about scientists		Bob Henzell, Primary Interface, Aust. Science Comp. (Yr. 8), Planetarium, Mine, Investigation, Lyn Brodie, Gary Young		
Role of science in society	Slight increase	TV news, Aust. Science Comp. (Yr. 8), Planetarium, Bob Henzell, Mine, Lyn Brodie, Gary Young	Perceived lack of media coverage	

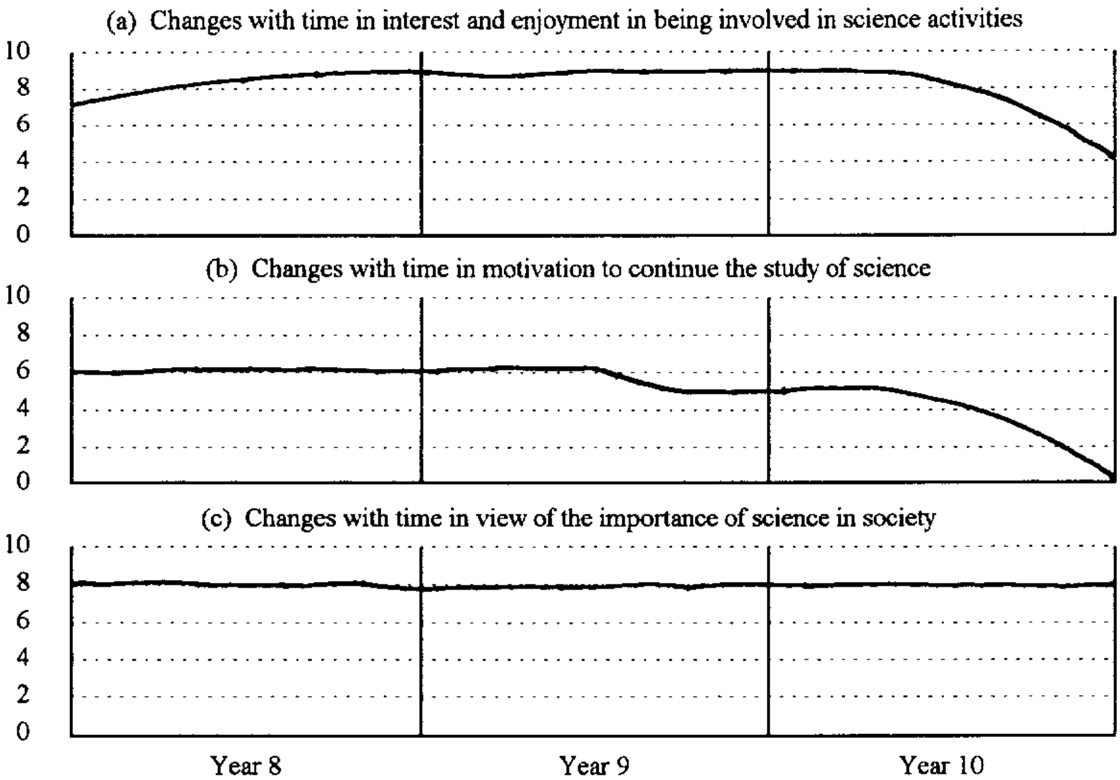

Figure 4.7. Graphs of retrospective trends: Jeff.

the greatest impact. The former was a new experience for him, during which he performed experiments taken from the course text, used the library, and manipulated Lego and other apparatus, often working with fellow students. He found the repeat of some class experiments an aid to understanding, saying that Evening Science made him think about science and become a lot more aware of science and that "there's always something to do." Perusing the Science Contest entries made him think a lot more about what he would be doing for his investigation the following year and motivated him to attend further Evening Science activities. Interestingly, Jeff said that Evening Science with Peter Walsh, while not having any effect on his overall interest and enjoyment in being involved in science activities, did have the effect of making him pay a little more attention during science lessons.

During Year 9, two activities increased his interest and enjoyment. He looked forward to Evening Science and continued with the same type of work as he did in Year 8. The hands-on nature of the *Sciencentre* activities compared, for example, with the passive visit to the coal mine, made a significant impact. However, Jeff said that he had visited the *Sciencentre* on two previous occasions and that the impact of the first visit was much greater. At that time he was in Year 7 (at a previous school) and the visit gave him the desire to do many more science experiments.

During Year 10 Jeff continued to participate, with continuing positive effects on his interest and enjoyment, in Evening Science, adding preparation for the Primary Interface and use of computer software to the types of activities he had performed in previous years.

> Evening Science is probably the thing that I like most about science because it gives you a chance to do things that you want to do and everything and do your own experiments and yet more time than you do in class. You don't have to rush.

However, Jeff's interest and enjoyment in being involved in science activities decreased (Figure 4.7a) after he made a decision to choose a non-science career in the areas of finance and business, rather than continue with science.

Motivation. Jeff's motivation to continue to participate in science decreased, to a very low level, during his junior years (Figure 4.7b and the dramatic fall in Rating Scale score from about 7.0 to about 2.0 in Figure 4.15). However, Jeff said during his Year 9 interview that his motivation had increased since Year 8 because he had been attracted by some of the experiments he had seen senior students performing.

Many science activities (and particularly activities in Year 8) contributed positively to Jeff's motivation. After being pleased at receiving a credit in the Australian Schools Science Competition in Year 8 and having the desire to do even better in following years, he thought that high future achievement might make him think about doing science past Year 12. Exposure to entries during the Science Contest Excursion made him think that, if he had some good ideas, he could perhaps work on similar innovations (and hence continue science) after school. Evening Science with Stephen Sexton similarly attracted him to the idea of being responsible for an invention like the insect control technique outlined during the evening. Evening Science with Peter Walsh (his first such evening) not only motivated him to come to future Evening Science With a Guest sessions but "made me think that, if you went into that area of business and had your own company or something there's money to be made." It appears that Jeff was an entrepreneur in the making! However, the activity which made the greatest impact on his motivation during Year 8 was Evening

Science. He was fascinated by the use of Lego equipment to investigate, for example, variables affecting the hill-climbing ability of vehicles. Doing different experiments made him think about the variety of future opportunities in science and "probably made me think a little more about continuing my career in science."

The Australian Schools Science Competition in Year 9 did not affect Jeff's motivation but "when I got the distinction you know I realized that, you know there might be something there for me in science" and while he said that his first visit to the *Sciencentre* increased his motivation a large extent (because he didn't do many experiments in school and this activity made him want to), the visit this year had not.

After doing very well in the National Chemistry Quiz in Year 10, Jeff was motivated a little, and encouraged by both peers and parents, to pursue a career in chemistry. His result made him think about the implications of this, including asking himself: "What else would I miss out on? Would it be worth it? How well would I do?" Finally, Jeff's motivation to continue to participate in science plummeted after he made his non-science business-oriented senior subject choices with a view to a future as, for example, a financial adviser, business analyst, or stockbroker.

Scientists. During interview at the end of Year 8 Jeff said:

> A scientist is a person who devotes their career to science and, I don't know, explores the possibilities of what science can do for us . . . A scientist can be any person. A lot of people think that they just go around in laboratories with glasses and stuff but a scientist can be anybody really . . . They're just like everybody else.

He was exposed to a range of practitioners (especially during Year 8) and he said that each experience broadened his perception of the roles in which scientists are involved. The Science Contest Excursion made him think that the work of scientists involves technologies such as electronics and not just chemicals and laboratories, the Planetarium visit made him realise that astronomy was part of science and made him think about the many people who have scientific roles apart from those who "just work in laboratories," and Evening Science with Peter Walsh, Tom Kirkpatrick, and Bob Henzell all had a similar broadening effect specific to their area of expertise, as did the USQ Seminar in Year 10.

Science in society. Jeff said that while his view of the importance of science in society was high and did not change during his junior years (Figure 4.7c), many science activities broadened his perception of the contribution of science to society by highlighting areas of which he was previously unaware.

Jeff's Year 8 view of the role of science in society was that "science has got us pretty far today . . . without science we wouldn't have a lot of the things that we've got" and science has made life easier by creating, for example, chemicals and other products which help farmers in their work. During Year 8, the Australian Schools Science Competition made him aware of the implications of ultraviolet radiation research, Evening Science involved experiments that showed "different things about what scientists were doing in society and how they were hoping to make things better or fix the ozone layer up," and entries he saw during the Science Contest Excursion involving, for example, a movement alarm and a safety iron showed him how science could help people. At the Planetarium he became aware of how the invention of telescopes allowed planets and other heavenly bodies to be studied and, by relating this with television commercials for a program dealing with the creation of the Universe, showed him the contribution that astronomy can make to society. Evening Science with Peter Walsh, Tom Kirkpatrick, Stephen Sexton, and Bob Henzell all introduced him to avenues of scientific endeavour of which he was previously unaware.

During Year 9, the Mine and *Sciencentre* Excursions had similar broadening effects, the latter in relation to the contribution of physics in particular. In relation to the Australian Schools Science Competition he said:

> Some of the graphs and things that we had to interpret I thought would have been mainly involved in other fields rather than science such as maths, but, um, it turned out they were science and I was a little bit surprised in that.

For his Investigation, Jeff attempted to study any link between the diet (health food versus junk food) and intelligence (as measured by ability to find a way through a maze) of mice. He said this activity broadened his view of the role of science in society because it made him think of other ways in which tests with mice could be used beneficially. He said that the Year 10 USQ Seminar and Evening Science with both Gary Young and Phil Webb had similar broadening effects.

Summary. A summary of the data for Jeff is given in Table 4.19.

Table 4.19
A Summary of the Data for Jeff

Dependent variable	Overall trend	Contribution to variable		Longer-term effects
		Positive effect	Negative effect	
Interest and enjoyment	Decrease	Novelty of classwork, Aust. Science Comp. (Yr. 8), Planetarium, Evening Science (Yr. 8, 9, 10), Science Contest Excursion, *Sciencentre*	Decision on a non-science future	
Motivation	Decrease	Senior experiments, Aust. Science Comp. (Yr. 8), Science Contest Excursion, Stephen Sexton, Peter Walsh, Evening Science (Yr. 8), *Sciencentre* (previous visit), Nat. Chem. Quiz	Decision on a non-science senior course and career.	
Perceptions about scientists		Science Contest Excursion, Planetarium, Peter Walsh, Tom Kirkpatrick, Bob Henzell, USQ Seminar		
Role of science in society	No change	Aust. Science Comp. (Yr. 8, 9), Evening Science (Yr. 8), Science Contest Excursion, Planetarium, Peter Walsh, Tom Kirkpatrick, Stephen Sexton, Bob Henzell, Mine, *Sciencentre*, Investigation, USQ Seminar, Gary Young, Phil Webb		

Richard

Richard began boarding at the school in Year 8. He was an A/B-achieving student whose effort and conduct and cooperation were consistently of a high standard. He participated in seven enrichment activities, four extracurricular activities, and, in addition, attended Evening Science on 11 occasions.

Interest and enjoyment. Richard's interest and enjoyment in being involved in science activities increased during his junior years (Figure 4.8a).

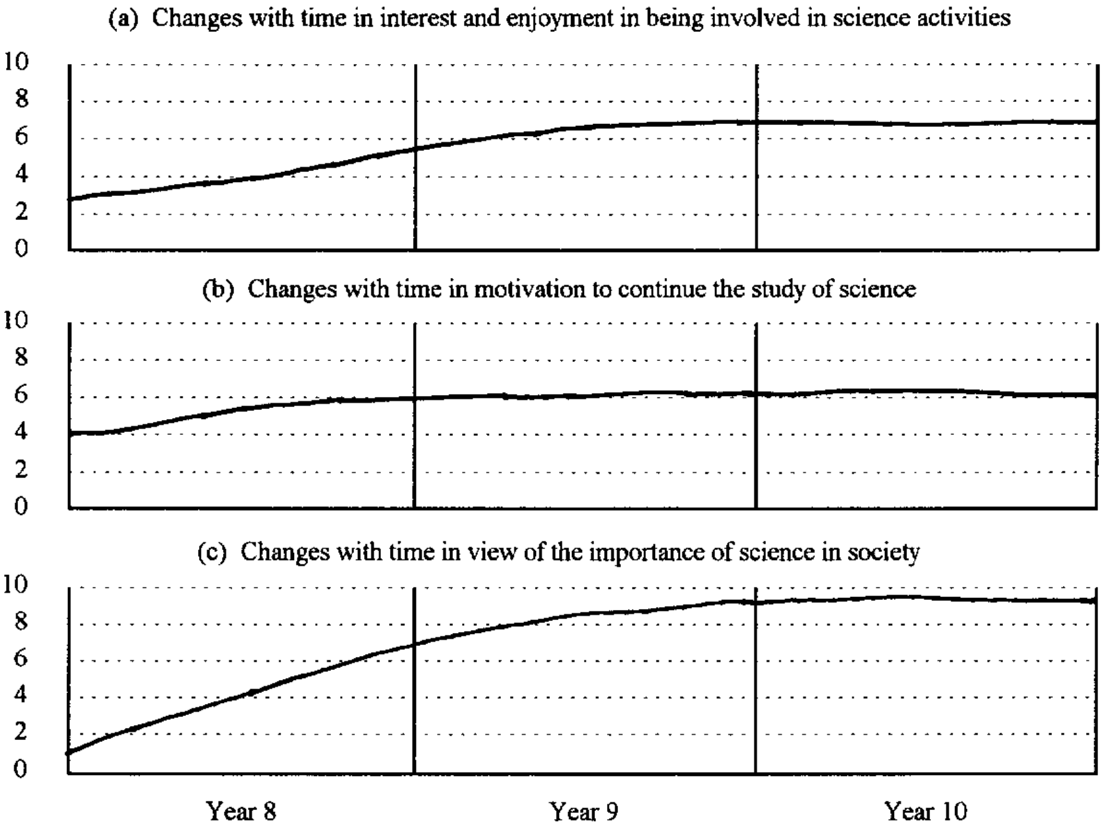

Figure 4.8. Graphs of retrospective trends: Richard.

Richard's primary school experience was via School of the Air and lessons by correspondence, and he said he required a little time to settle in at boarding school. During this settling-in period early in Year 8 he said he was not interested in many things, including science, but that his interest and enjoyment increased after he had settled in.

During his junior years the following activities all made positive contributions to his interest and enjoyment in being involved in science activities: Evening Science, Year 8 (because he preferred doing experiments to the written work which was also involved in classwork), the Science Contest Excursion (he saw an entry involving preservation of water and was thinking about doing something similar for his Year 9 Investigation), the Planetarium (because he learned much and it broadened his perception of the possible areas for study in this field of science), his Investigation (he was happy that he had thought of the idea of constructing a movement alarm and that, after earlier doubts, he was able to complete the project), the National Chemistry Quiz (because it broadened his view of the topics which comprised chemistry), the USQ Seminar (he found it interesting), and the Phil Webb evening (because he found how satellites work interesting). Richard also said that, in accord with Table 4.14, his interest and enjoyment increased from Year 9 to 10 as a result of him finding science classwork more interesting in Year 10.

Motivation. Richard said that his motivation to continue to participate in science increased during his junior years (Figure 4.8b) as a result of the increase in his interest and enjoyment. The following activities contributed positively to his motivation for the reasons given: the Australian Schools Science Competition, Year 8 (because it "made me think about how many things [i.e. employment opportunities] I could do when I get older"), Evening Science (he saw older students doing experiments which looked interesting), Science Contest and Mine Excursions (both broadened his perception of the type of work science can involve), the Planetarium and *Sciencentre* Excursions (both interested him), and his Investigation (made him think a little more about doing a senior science).

Richard said that at no stage during his junior years did he have any tertiary course or career thoughts. Classwork during Year 9 made him think about doing Senior Chemistry. Richard finally enrolled in Senior Physics.

Scientists. In Year 8 Richard thought that scientists were "quite smart" and that both males and females do well at science. The Science Contest Excursion broadened his perception of the work of scientists and both this activity and the Planetarium Excursion led him to believe that they were harder-working people than he previously thought; in particular, working towards making the world a better place (e.g. working on the ozone-layer problem).

Science in society. Richard's view of the importance of science in society increased to a very high level during his junior years (Figure 4.8c). While settling in to boarding school, Richard said he "didn't really care about it [science]." By the end of Year 8 he had the view that science contributed to helping society, including trying to solve problems such as the greenhouse effect, and this view remained with him during his junior years. The following activities enhanced his view of the importance of science in society: the Australian Schools Science Competition, Year 8 (showed him how science can "prevent bad things from happening"), the Science Contest Excursion ("You see so many entries in there and how they are all trying to help the future and things."), the Planetarium Excursion ("Just to study the other planets to maybe even be able to, be able to get humans to be able to live on another planet."), Mine visit (showed the positive contribution of science and mining to society), the Phil Webb Evening (showed how satellites have contributed to television reception), and classwork and videos (via inclusion of topics such as acid rain).

Richard also said that, during Year 9, while he continued to think that "scientists sorta try to make it better for everyone" he also formed the opinion that "sometimes it sorta backfires a bit," giving the human suffering caused by the invention of the nuclear bomb as an example.

Summary. Table 4.20 summarises the data for Richard.

Table 4.20
A Summary of the Data for Richard

Dependent variable	Overall trend	Contribution to variable		Longer-term effects
		Positive effect	Negative effect	
Interest and enjoyment	Increase	Evening Science (Yr. 8), Science Contest Excursion, Planetarium, Investigation, Nat. Chem. Quiz, USQ Seminar, Phil Webb, classwork.		
Motivation	Increase	Aust. Science Comp. (Yr. 8), Evening Science, Science Contest Excursion, Mine, Planetarium, *Sciencentre*, Investigation.		
Perceptions about scientists		Science Contest Excursion, Planetarium.		
Role of science in society	Increase	Aust. Science Comp. (Yr. 8), Science Contest Excursion, Planetarium, Mine, Phil Webb, classwork and videos		

Talbot

Tabot entered Glendale College as a boarder in Year 8. His science achievement was of a B standard during Years 8 and 10 but C standard in Year 9, while his effort and conduct and cooperation ratings were 2/3. Talbot participated in three enrichment activities and nine extracurricular activities, as well as attending Evening Science on 17 occasions.

Interest and enjoyment. Talbot's high interest and enjoyment in being involved in science activities decreased during Year 9 but subsequently increased to a high level (Figure 4.9a). During interview Talbot said that he enjoyed science very much during Year 8 and that the following activities had the effect of increasing his interest and enjoyment for the reasons given: the Australian Schools Science Competition, the Science Contest Excursion, and the Planetarium all provided interesting and novel

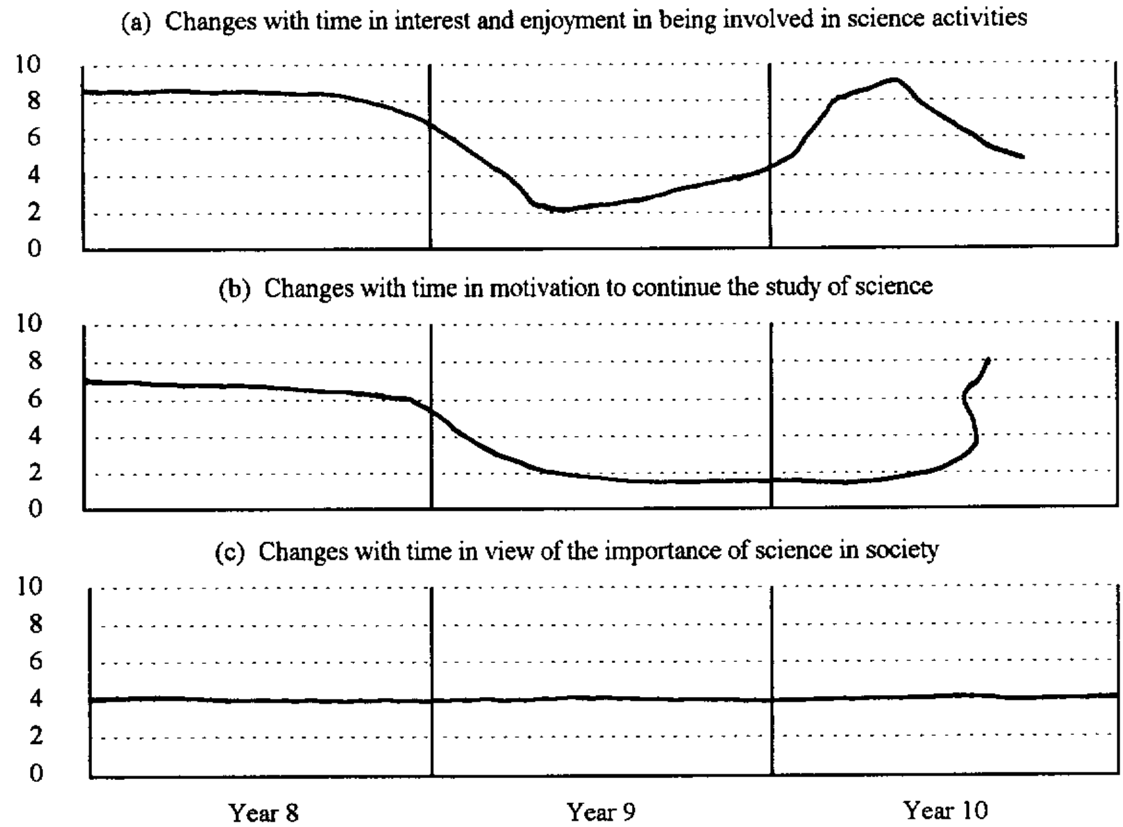

Figure 4.9. Graphs of retrospective trends: Talbot.

experiences, during Evening Science he "got to experiment with my own things, what I wanted to find out," and the Stephen Sexton and Bob Henzell Evenings both involved concepts which he could relate to the crops grown by his parents at home.

Talbot's interest and enjoyment decreased markedly in Year 9 as a result of his dislike for his science teacher's teaching style and personality. He had the same teacher for the entire year. However, having positive effects in this domain during this year were his credit award in the Australian Schools Science Competition, Evening Science (for the same reasons as in Year 8), and to a greater extent, the visit to the *Sciencentre* "because I enjoyed doing the different kinds of experiments and, or what they're showing you."

Talbot said his increase in interest and enjoyment in Year 10 was mainly the result of a change to different teachers, but that the Australian Schools Science Competition (because he was awarded a distinction), Evening Science (for the same reason as in earlier years), and the USQ Seminar (because "there were a lot of interesting things to do") also contributed positively. Although invited to do so, he offered no reason for the decrease shown in Figure 4.9a towards the end of Year 10.

Motivation. Talbot's motivation to continue to participate in science decreased and then increased during his junior years (Figure 4.9b). It was high during Year 8, buoyed by the Planetarium Excursion (because it was interesting and introduced him to another branch of science that he could pursue) and, to a greater extent, Evening Science (because of the autonomy it provided).

His motivation dropped early in Year 9 for the same reason as his interest and enjoyment dropped and, in contrast to the latter, did not rise again until towards the end of Year 10. He decided that he would like to pursue further studies in engineering and that he needed to study senior chemistry and physics. The USQ Seminar, by increasing his interest and motivation in this area, reinforced his desire to pursue engineering. Talbot chose Chemistry and Physics as senior subjects.

Scientists. Talbot's Year 8 view of scientists as either male or female investigators and inventors, aiming to "just help the world and . . . invent better [improved, novel] things" remained unchanged during his junior years. However, the Australian Schools Science Competition, Evening Science in Year 8, the Science Contest Excursion, and the evenings with Bob Henzell and Stephen Sexton all broadened his perception of the variety of work in which scientists are engaged. In regard to the latter activity, he also said that he "just thought that a scientist would only spend a few months on one subject, not, you know, sit on it for years trying to work out, work it out how to stop it."

Science in society. In accord with Figure 4.9c and Table 4.17, Talbot said his Year 8 view of science as contributing positively to life on Earth via inventions and the creation of new "substances and things like that" did not change during his junior years. However, he also said that Evening Science in Year 8, the Stephen Sexton and Bob Henzell evenings, and the Science Contest Excursion all broadened his awareness of the contribution of science to society and, by so doing, tended to increase his view of the importance of science in society.

Summary. A summary of the data for Talbot is given in Table 4.21.

Table 4.21
A Summary of the Data for Talbot

Dependent variable	Overall trend	Contribution to variable		Longer-term effects
		Positive effect	Negative effect	
Interest and enjoyment	Decrease and increase	Aust. Science Comp. (Yr. 8, 9, 10), Science Contest Excursion, Planetarium, Evening Science (Yr. 8, 9, 10), Stephen Sexton, Bob Henzell, *Sciencentre*, USQ Seminar	Teacher style/personality	
Motivation	Decrease and increase	Planetarium, Evening Science (Yr. 8), USQ Seminar, career goal	Teacher style/personality	
Perceptions about scientists		Aust. Science Comp. (Yr. 8), Evening Science (Yr. 8), Science Contest Excursion, Bob Henzell, Stephen Sexton		
Role of science in society	Increase	Evening Science (Yr. 8), Stephen Sexton, Bob Henzell, Science Contest Excursion		

Warwick

Warwick entered the school as a boarding student in Year 8 and proceeded to achieve in science at an A/B level during his junior years. His effort and conduct and cooperation were both high during this time, with the exception of one 4 rating (poor) for effort in Semester 1, Year 9. He participated in seven enrichment activities and eight extracurricular activities, the latter including attendance at Evening Science on one occasion.

Interest and enjoyment. Warwick's interest and enjoyment in being involved in science activities increased to a high level during his junior years (Figure 4.10a). Warwick said the variations in his interest and enjoyment reflected the degree to which he liked different classwork topics. Also making a positive contribution to his interest and enjoyment during second semester, Year 8 was the visit to the Hermitage because, although he had the idea earlier, it "sparked on the idea about studying our

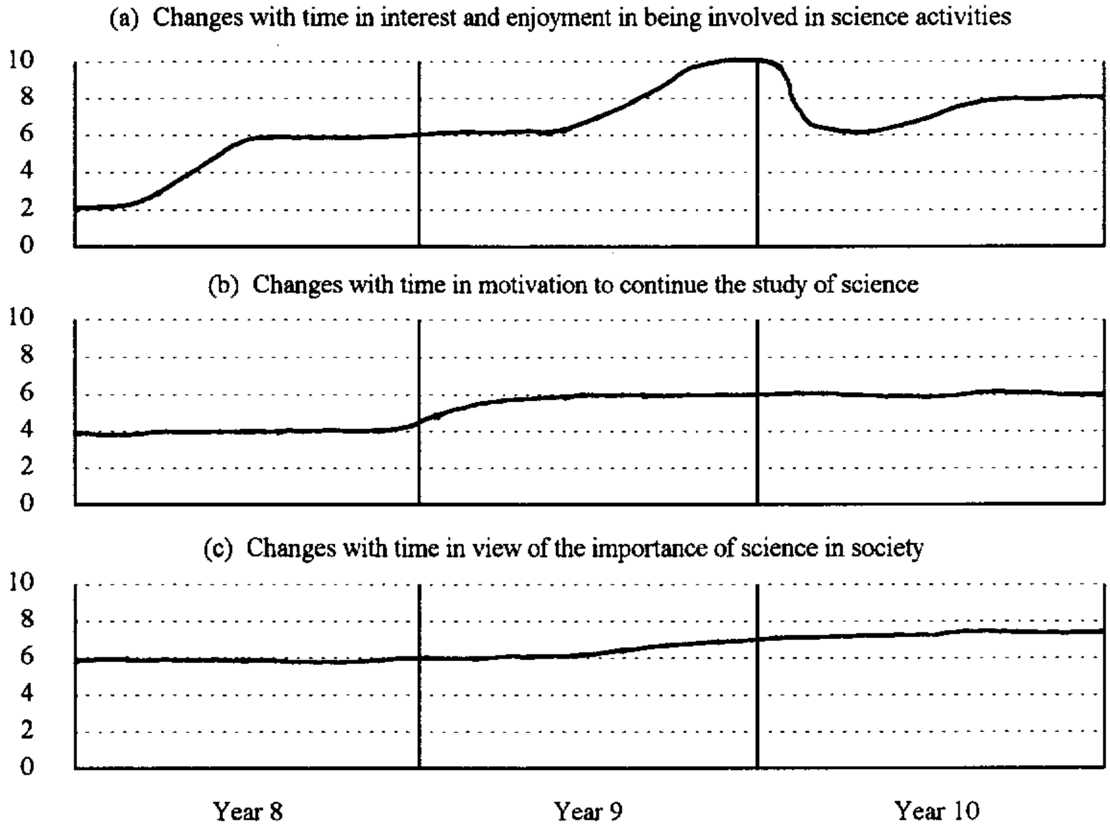

Figure 4.10. Graphs of retrospective trends: Warwick.

new breed [cattle on his parents' station]." He subsequently chose this as the focus for his Year 9 investigation.

During the second half of Year 9, Warwick said he found science classwork topics very interesting, with work on his Year 9 Investigation also making a very positive contribution. This investigation involved the cross-breeding of cattle on his parents' station and gave him a detailed understanding of this work, with which he helped during vacation periods. He said that the visit to the Hermitage the previous year was still having the effect of making him more interested in sorghum breeding than would otherwise have been the case, but was not having this same effect on his interest and enjoyment in science activities in general.

Motivation. Warwick's overall increase in motivation, during his junior years, to continue to participate in science (Figure 4.10b) was due to a range of influences, most of which related to his perceived career path. In Year 8, by which time Warwick's parents had previously queried him about studying for a degree in agricultural science, one question on the Australian Schools Science Competition paper which dealt with breeds of animals motivated him towards pursuing such a degree. Work involving chemical reactions during Evening Science motivated him in his approach to classroom science as it increased his desire to "find out more about chemical reactions."

During Year 9, discussion with his parents about a combined agriculture/economics tertiary course had a large positive effect. The Australian Schools Science Competition increased his desire to study biology during his senior years. "Just a couple of questions on there about biol. that looked fairly interesting, biol. is really to do with anything that lives and you can't have anything without something that lives." The fact that some of the questions dealt with environmental concerns and that he is "rapt" in ecology reinforced his already strong desire to pursue a future career in agriculture. The Investigation had a similar reinforcing effect and made him think about "broader ranges of agriculture and animal husbandry." Also having a positive effect during Year 9 was information provided by his teachers about vocational areas to which a study of science can lead.

By Year 10 Warwick had found a tertiary institution which offered a degree course with majors in agriculture and economics and had settled on biology and chemistry as senior science subjects because they were pre-requisites for the course.

Scientists. Warwick's Year 8 view of a scientist was of a person, either male or female, wearing a white coat and sitting in a laboratory "playing" with chemicals and glassware. "They don't do anything else, all the movies I've seen, they don't do anything else except science . . . . They always think on the complex side of things. Like if somebody says 'that mug's full of tea', they'll think what's in the tea, sugar, and whatever element sugar is."

Contrary to the trend shown in Table 4.16 Warwick said during his second interview that this view had changed. "They don't always sit in a lab all day, they can go out . . . they're normal . . . they are just like other people." He said this revised perception was the result of watching videos and television programs and contact with a demonstrator (which he likened to a scientist) during the *Sciencentre* visit: "she was just normal like everyone else."

The Tom Kirkpatrick evening, Hermitage visit, Science Contest, *Sciencentre*, and Mine excursions, and Phil Webb and Lyn Brodie evenings all broadened

Warwick's view of the type of work in which scientists and engineers are engaged, and the first two activities made him aware that scientists' work can extend out-of-doors.

Finally, both the Australian Schools Science Competition (Yr. 8) and the Science Contest Excursion gave him the impression that scientists work hard and "always stick to their work, they don't rest until it's done," the Planetarium visit demonstrated that scientists use interesting equipment, and the Lyn Brodie evening alerted him to the fact that, contrary to his prior view, engineering was not a male-only vocation.

Science in society. Warwick's view of the importance of science in society increased during his junior years (Figure 4.10c). In Year 8 he considered the role of science in society to be significant, saying that without science society would not have technologies like tape recorders and breeding programs, based on an understanding of genetics, such as that being carried out on his parents' station. Science can "make life easier for people, sometimes harder when they think up disasters [e.g. bombs] and diseases [i.e. discovery of a new disease causes people to worry] and that."

Warwick said that two factors increased his view of the importance of science in society during his junior years. These were knowledge gained from library reading of materials such as the *Beyond 2000* books and the Hermitage visit, which made him realise that society wouldn't have the superior sorghum plants that exist today without the type of research to which he was exposed.

Both the Australian Schools Science Competition in Year 8 and the Tom Kirkpatrick Evening broadened Warwick's perception of the role of science in society. In regard to the former he said he "found out that, like I thought science was just mixing chemicals together and all that but it's on, the animal kingdom, plant kingdom, the respiratory system and all that, the gases in the atmosphere and all that" and, in regard to the latter, that he "didn't really know that science monitored kangaroos."

Summary. Table 4.22 summarises the data for Warwick.

Table 4.22
A Summary of the Data for Warwick

Dependent variable	Overall trend	Contribution to variable		Longer-term effects
		Positive effect	Negative effect	
Interest and enjoyment	Increase	Classwork topics, Hermitage, Investigation	Classwork topics	Hermitage
Motivation	Small increase	Aust. Science Comp. (Yr. 8 & 9), Evening Science (Yr. 8), Investigation, teachers creating awareness of opportunities, discussion with parents about tertiary course		
Perceptions about scientists		Aust. Science Comp. (Yr. 8), Tom Kirkpatrick, Hermitage, Science Contest Excursion, Planetarium, *Sciencentre*, Mine, Phil Webb, Lyn Brodie		
Role of science in society	Small increase	Aust. Science Comp. (Yr. 8), Tom Kirkpatrick, Hermitage, library books		

In the next chapter, the data for these 10 students are analysed across students in two different ways. First, each dependent variable is considered in turn and conclusions about how and why they changed are developed. Then, the effects of individual science activities on these variables are considered.

CHAPTER 5

Results and Analysis: Junior Sample, Phases 2 and 3

This chapter reports the second and third phases of data analysis for the junior sample students. In Phase 2, each dependent variable is considered in turn. Data from the 10 junior sample students are used to address the first and second research questions by developing a set of generalisations related to changes in each dependent variable. Then, in Phase 3, a further set of results about the effects of individual enrichment and extracurricular science activities (the third research question), grouped in the overlapping categories of competitions, excursions, practical work, and guest evenings, is developed.

The general structure adopted is to draw the evidence into a generalisation and then discuss it. The discussion typically provides evidence to support the generalisation and an acknowledgement, if possible, of counter evidence.

5.1 Interest, Enjoyment, and Motivation

How These Variables Changed

The overall trend (i.e. increase, no change, or decrease) in the motivation of each student to continue to participate in science during their junior years correlates strongly with the trend in each student's interest and enjoyment in being involved in science activities. Because of this relationship between interest and enjoyment and motivation, which is in accord with the literature reviewed in section 2.3, these two dependent variables will be discussed jointly. In the case of only two students was the trend in these two variables not identical; the trend in Henrietta's motivation opposed that in her interest and enjoyment during part of the study period only and Hugh experienced no overall change in motivation yet an increase in interest and enjoyment.

The interest and enjoyment of junior sample students, as a group, in being involved in science activities increased slightly during the study period. The interest and enjoyment of five students (Henrietta, Zita, Hugh, Richard, and Warwick) increased, that of Rebecca and Talbot did not change significantly, and Angela, Kate, and Jeff experienced a decrease in interest and enjoyment. There was no change in the motivation of junior sample students, as a group, to continue to participate in science; the motivation of three students increased, that of four students did not change in an overall sense, and the motivation of three students decreased during the study period.

There appears to be no relationship between trends in students' interest and enjoyment or motivation and their achievement in science. Of the five students whose interest and enjoyment increased, Henrietta, Hugh, Richard, and Warwick had A- or B-level science achievement during their junior years and Zita's achievement dropped from a B to D/C level. The two students for whom interest and enjoyment did not change achieved typically at a B level. Of the three students whose interest and achievement decreased, Angela and Jeff were achieving at B and A levels respectively and Kate's achievement dropped from a C to an E during her junior years.

Why These Variables Changed

Participation in enrichment and extracurricular science activities was given as the most frequent contribution to the increase in both students' interest and enjoyment in being involved in science activities in general and their motivation to continue to participate in science. Without exception, and hence regardless of the overall trend in a student's interest and enjoyment, at least one activity made a positive contribution to each student's interest and enjoyment. In all, there were 54 instances out of a possible 124 opportunities (i.e. the number of person-activity combinations), involving 16 of 23 activities, of such positive contributions to the interest and enjoyment of the 10 students. In fact, the high level of choice, most noticeably by the junior boys, to be involved in extracurricular science activities during all of their junior years (Table 4.13) indicates a high level of interest in science within this group. There was only one instance in which an activity made a negative contribution to the interest and enjoyment of a student; the Year 9 Investigation by Henrietta.

For 9 of the 10 students, at least one activity made a positive contribution to their motivation. In all there were 35 instances (in the total 124 opportunities), involving 14 of the 23 activities, of positive contributions to the motivation of these nine students. There were only three instances, involving three different students and three different activities, of activities having a negative effect on motivation. Details of the effects of individual activities are addressed in Phase 3 of data analysis reported later in this chapter.

The next most frequent contribution, both positive and negative, to students' interest and enjoyment was made by classwork-related factors. Positive effects resulted from classwork (either the content of the topics themselves or the nature of the learning experience, such as increased practical work) being perceived as interesting (one girl and two boys) and from increased understanding of the concepts addressed during science classes (two girls). However, a dislike of the course topics (two girls and one boy) and the finding of coursework difficult (three girls) made negative impacts. Other negative contributions to interest and enjoyment included teacher style and personality, a decision on a non-science future, and a poorly equipped, uninviting, and uncomfortable room.

The reasons for students' changes in motivation to continue to participate in science (including the effects of science activities) can be considered affective or utilitarian, in accord with the categories used by Woods (1979) (section 2.3). Affective reasons were all positive (i.e. tended to increase motivation) and include comments by students about interest and enjoyment, fascination, like of topics, a link with work at home on the farm, own choice, desire to do better the following year, desire to innovate, autonomy, and, in the case of Henrietta, the feeling that the lack of chemistry she perceived on her Year 8 Australian Schools Science Competition paper motivated her to study chemistry because she felt that people needed to know about this subject.

Utilitarian reasons include a number of career-oriented contributions, as well as the receipt of an award and, from a negative perspective, difficulty in understanding coursework and a poor academic result, with Henrietta adding the difficulty for boarders, especially, in completing the Year 9 Investigation as another negative contribution. Career-oriented reasons include broadening of students' perceptions of career opportunities in science-based vocations (including the career information provided to one student by teachers), adoption of a science-based career or otherwise (the latter being a negative contribution), keeping career options open, a career prerequisite, and money to be made.

All the boys and three of the five girls were influenced by affective considerations and all the boys and four girls were influenced for utilitarian reasons. Within the latter category, four of the five boys and only one girl (Zita) were influenced for career-oriented reasons.

5.2 Perceptions About Scientists

How This Variable Changed

Nearly all the junior sample students described scientists in normal terms, and the majority of these students said they had those perceptions from the beginning of Year 8. Only Angela and Warwick mentioned negative stereotypical factors during the study period and Warwick said that this perception had quickly been negated. Further, half of the students held positive stereotypical perceptions about scientists during at least part of, or the whole, study period.

Why This Variable Changed

Participation by students in the enrichment and extracurricular science activities had the most frequent, and only broadly applicable, effects on their perceptions about scientists. There were 41 instances (out of a possible 124) of such effects involving 9 of the 10 students and 17 of the 23 activities, and a synthesis of the nature of these effects is found later in this chapter. Other influences on students' perceptions about scientists were books, television, and coursework.

5.3 Role of Science in Society

How This Variable Changed

The Year 8 perceptions of students about the role of science in society acknowledged the important contribution which science makes to people's lives. All 8 of the 10 students interviewed in Year 8 expressed this view, exemplified by the following sentiments: science assists with Ethiopia's drought, improves the land, helps cope with disease, cures diseases, strives to make the world a better place, makes life easier, creates new substances, solves problems like the greenhouse effect, and has made technologies like tape recorders and artificial-breeding programs possible.

Further, the views of eight students about the importance of science in society increased during their junior years, with six of these eight students choosing to study at least one senior science subject. The other students, Jeff (no change) and Kate (a decrease), were also two of only the three students who experienced a decline in both their interest and enjoyment and their motivation during their junior years.

Why This Variable Changed

Participation in enrichment and extracurricular science activities seem to have had a broad positive effect (36 instances in 124 possibilities involving 17 of the 23 activities and 8 of the 10 students) on changes in students' perceptions of the role of science in society. Here, a positive effect was considered to be one which broadened a student's perception of the role of science in society and/or increased their view of the importance of science in society. Further details about these effects of the activities are given later in this chapter.

Other positive effects stemmed from the media (television news, newspapers, *Beyond 2000* (a television program), library books, coursework, the death of close persons, peers, and other persons outside the school environment. Kate, the only student whose view of the importance of science in society decreased during her junior years, reported the only negative contribution to this variable; her dislike of science.

The final sections of this chapter address Phase 3 of the analysis of data, where the effects of individual enrichment and extracurricular science activities (grouped as competitions, excursions, practical work, and guest evenings) are considered.

5.4 Competitions

Competitions include the Australian Schools Science Competitions (Years 8, 9, and 10) and the National Chemistry Quiz (Year 10 only). In both cases, questions are set and answers are marked externally to schools, with awards to students determined using norm-based criteria.

Interest, Enjoyment, and Motivation

Participation in the Australian Schools Science Competitions and the National Chemistry Quiz had significant short-term positive effects on both junior students' interest and enjoyment in being involved in science activities and their motivation to continue to participate in science. Such a positive effect was experienced by students

18 times in 34 possible opportunities (8 out of 14 for girls and 10 out of 20 for boys) spread across both activities (12 out of 20 in the Australian Schools Science Competitions and 6 out of 14 in the National Chemistry Quiz). No student reported any negative, or longer-term, effect on their interest and enjoyment.

Of the reasons given for this positive effect, receiving an award was the most prominent, applying to 4 of the 8 times a girl received an award and 4 of the 18 times for boys. Other reasons for the positive effect of the Australian Schools Science Competitions included interesting and novel questions, content which increased curiosity and was related to everyday-life experiences, positive reinforcement or broadening of future career opportunities in the sciences, and the little emphasis perceived to be given to chemistry questions. For the National Chemistry Quiz, broadening a student's view of the topics which comprise chemistry and not finding the quiz too difficult were reasons given for positive effects.

Only two negative influences were reported, both involving motivation. Hugh said that the biology questions in the Year 9 Australian Schools Science Competition "steered me away" from the future study of biology, and Zita, as a result of perceiving her National Chemistry Quiz result to be poor, concluded that chemistry was "not for me."

Significantly, the majority of students who experienced a positive effect on their interest and enjoyment and their motivation as a result of sitting for the Australian Schools Science Competition did so in conjunction with their first sitting only, with subsequent sittings having no cumulative effect. In terms of interest and enjoyment, this applied to four of the six students who experienced a positive effect. In the other two cases, the subsequent positive effects were due to either receiving an award for the first time or receiving a higher award. This "first-time-only" situation also described four of the six students who had their motivation increased as a result of the competition. Of the others, Warwick said that both the first and second sittings (of three) positively affected his motivation and Rebecca experienced an increase in motivation as a result of receiving a much higher award after her third sitting.

Scientists

Participation in the Australian Schools Science Competitions (which involved all 10 students in each of Years 8, 9, and 10) broadened Hugh's and Talbot's perceptions of the type of work in which scientists are engaged and Warwick reported that the competition led him to believe that scientists must be hard workers who persist with the task at hand. Again, these effects were experienced in conjunction with the first sitting only in the competition, which also had no effects on the girls' perceptions about scientists. The National Chemistry Quiz had no effects on any student's perception about scientists.

Science in Society

Their first sitting of the Australian Schools Science Competition broadened the perceptions of four of the five boys about the role of science in society. The effects included an awareness of the implications of ultraviolet radiation, an awareness of fields of science study such as atmospheric gases, and an awareness of the role of science in preventing undesirable occurrences. In some cases, this broadening effect also increased the student's view of the importance of science in society. No such effects were reported by any girl, and the National Chemistry Quiz had no effects on the perception of any student about the role of science in society.

5.5 Excursions

Excursions include the Science Contest and Planetarium Excursions (Year 8), the *Sciencentre* and Mine Excursions (Year 9), together with the USQ Seminar (Year 10); all activities which required students to travel to off-College-campus venues.

Interest, Enjoyment, and Motivation

The Science Contest, Planetarium, and *Sciencentre* Excursions were equally effective in positively influencing the interest and enjoyment (20 times in a total of 28 possible opportunities) and, to a lesser extent, the motivation of students (10 times in the 28 opportunities), while the Mine Excursion was less effective (2 positive influences on interest and enjoyment in 10 opportunities and 1 in 10 on motivation). While the first three excursions most frequently had this effect because students found them interesting and/or enjoyable, some other reasons for this positive effect on either interest and enjoyment or motivation were given. For the Science Contest Excursion, students reported that it showed that science can be fun, involved novel experiences, included some exhibits related to work father was doing at home, made Jeff think that if he had some good ideas he could perhaps work on similar inventions after school years, broadened Richard's perception of the type of work which science can involve, demonstrated that anyone, as opposed to a "brain" only, can do science (two students), and gave two students an idea for their Investigation the following year. The Planetarium Excursion had some positive effects because it involved novel experiences and broadened the perceptions of two students about possible fields of study which could be pursued in the sciences. Also, Richard said he learned much from it. The *Sciencentre* Excursion effects were attributed to the hands-on nature of the activity (two students), the opportunity to find things out for yourself, and novel experiences. The two reasons given for the positive effect of the Mine Excursion were that it was interesting and that it broadened the perception of the type of work science can involve.

The Planetarium and *Sciencentre* Excursions had a longer-term effect on the interest and enjoyment and/or motivation of Henrietta and Rebecca. The USQ Engineering and Surveying Seminar, an extracurricular activity, increased the interest and enjoyment and/or motivation of two of the three boys who chose to attend; once again because they found it interesting.

Scientists and Science in Society

The most common effect on students of the five excursions in these areas was that they broadened students' perceptions about both the type of work in which scientists engage (electronics as well as just chemicals and laboratories, astronomy, and environmental work) and the contribution of science in society (how science can help people, and the study of heavenly bodies informing about the creation of the Universe and working towards people living on another planet). These effects were more pronounced in conjunction with the Science Contest and Planetarium Excursions (three out of nine students in each case) and, to a slightly lesser extent, the Mine Excursion. Other effects of these activities on students' perceptions about scientists were as follows: for the Science Contest Excursion, they work hard (two students) and work towards making the world a better place; for the Planetarium Excursion, they work harder than previously thought and use interesting equipment; and for the *Sciencentre* Excursion, the work of scientists is more interesting than previously thought and they must be pretty brainy.

5.6 Practical Work

These activities each required students to engage in predominantly practical work and include the Investigation (Year 9), Primary Interface (Year 10), and Evening Science and Science Club (Years 8, 9, and 10).

Interest, Enjoyment, and Motivation

The Investigation, Primary Interface, and Evening Science all had significant positive effects on the interest and enjoyment of students (five out of nine students, four out of seven students, and four out of five boys [no girls chose to attend Evening Science], respectively). Of the students experiencing this positive effect, there were also significant accompanying increases in motivation; for three of the five students, two of the four students, and all four boys, respectively). Also, although Warwick said Evening Science had no effect on his interest and enjoyment, he said that his attendance on one occasion only increased his motivation by increasing his desire to find out more about chemical reactions. The reasons for the effect of the Investigation on interest and enjoyment included enjoying it, increasing understanding in an area of interest, and having own choice of question and method; for the Primary Interface, enjoying it and the sense of achievement associated with seeing others learn; and for Evening Science, student choice of what to do and the hands-on nature of the activity.

In contrast with the Australian Schools Science Competition and the National Chemistry Quiz, three of the four students who attended Evening Science during more than one year also had their interest and enjoyment positively affected as a result of attendance in a subsequent year, with only Richard experiencing a "first-time effect only." Henrietta was the only student for whom an activity, the Investigation, had a negative effect on interest, enjoyment, and motivation, due to a combination of lack of understanding of the requirements of the task and difficulties associated with being a boarder. On the other hand, the Investigation had a longer-term positive effect on Hugh's interest and enjoyment. Warwick was the only student to attend Science Club (during Year 10 only), evidently with no associated effects.

Scientists and Science in Society

The most common influence of the Investigation, Primary Interface, and Evening Science was that they broadened the perception of some students about the nature and variety of the work of scientists or about the role of science in society; Hugh and Jeff, Rebecca, and Jeff and Talbot, respectively. Again, Science Club had no effects in these areas. In addition, the Investigation showed Zita that a scientist's work could be fun and not just all hard work and Rebecca said the Primary Interface gave her a better idea about the role of scientists in conducting experiments and communicating results.

5.7 Guest Evenings

Here, the effects of the Evening Science With a Guest activities, comprising visits to the College by Peter Walsh, Tom Kirkpatrick, Stephen Sexton, and Bob Henzell during Year 8 and Gary Young, Phil Webb, and Lyn Brodie during Year 10 are addressed. Eight of the 10 junior sample students (all except Angela and Rebecca) attended at least one of the eight Evening Science With a Guest activities (for the purpose of the numbers only in this analysis, the Bob Henzell Evening and the follow-up Hermitage visit were regarded a single activity) with frequencies ranging from one to seven attendances among them. This gave 24 different possible student/activity combinations.

Interest, Enjoyment, and Motivation

The Evening Science With a Guest activities increased the interest and enjoyment or motivation of six of the eight participating students in 12 instances out of a possible 48 (each of the two variables could be affected on each of 24 occasions), for reasons which pertained primarily to the concepts covered by guests. The Bob Henzell Evening and Hermitage Visit had a longer-term effect on the interest and enjoyment of Hugh and Warwick, respectively.

Scientists

On 17 of the possible 24 occasions, Evening Science With a Guest affected seven of the eight students' perceptions about scientists. The most common effect (in 12 of the 17 cases) was one of broadening the student's view of the type of work in which scientists engage. On three occasions the activity reinforced or gave an impression of the normality of scientists and in the other two cases the activity reinforced or demonstrated the participation of women in engineering.

Science in Society

On all 15 of the 24 possible occasions where this activity influenced seven of the eight students in this area, Evening Science With a Guest broadened the view of a student about the role of science in society. In four of these cases, the activity also increased the student's view of the importance of science in society.

For ready reference, the effects on students (including senior sample students) of competitions, excursions, and practical work activities are summarised in tabular form in Appendices 8.A, 8.B, and 8.C, respectively. In the next two chapters, data for the senior sample students are reported and analysed; individual student case studies in Chapter 6 and then the second and third phases of data analysis in Chapter 7.

CHAPTER 6

Case Studies: Senior Sample

This chapter contains the results of the first phase of data analysis for senior sample students and is structured analogously to chapter 4, which dealt with the junior sample.

6.1 Background Information: Senior Girls

Biographical Details

Table 6.1 summarises the biographical details of the senior sample girls, many of whom entered Glendale College after the study began.

Participation in Activities

Table 6.2 summarises participation, in chronological order where appropriate, by senior sample girls in the enrichment and extracurricular science activities. Once again, only those activities which students chose to participate in, or nominate for, are listed.

6.2 Some Quantitative Data: Senior Girls

Tables 6.3 to 6.6 report the quantitative data from each survey instrument administered, plus the *Rating Scales* completed during interviews where applicable, for each dependent variable. For consistency, all scores given in the tables were again converted to scores out of 10. For Abi, Angel, and Wendy who entered the college in Year 11, the surveys which would have been administered in Year 10 were given to these students shortly after their arrival. These data are entered under the Year 11 results with the date of administration.

Table 6.1

Biographical Details: Senior Girls

Dimension	Student				
	Abi	Angel	Rachel	Ruth	Wendy
Status	Boarder	Boarder	Day student	Boarder	Boarder
Position in family	Third of three	First of two	First of three	First of three	First of three
Parents' occupations	Manager in sugar mill, unknown[a]	Fireman, business-woman	Dentist, doctor	Graziers	Bobcat hire, community development coordinator
Age	Typical[b]	2 yrs older than typical	Typical	Typical	Typical
Entry to college	Year 11	Year 11	Year 9, Term 2	Year 8	Year 11
Senior science subjects	Biology, Chemistry	Chemistry, Physics	Biology, Physics, Chemistry	Biology, Chemistry (Dropped Physics Sem. 2, Yr. 11)	Biology, Chemistry, Physics
Achievement	B/C	B (atypical D^+ for physics, Yr. 12 Sem. 2)	A	B→[c]C/D	C/D
Effort	1/2	1/2	1	1	1/2
Conduct and cooperation	1	1	1	1	1
Tertiary course	B.Arts	Unknown	B.Vet.Sc.	B.Ag.Ec.	Ass. Deg. Clinical Techniques

[a]No data given on survey form about mother's occupation, and this was not realised till after cohort had left the school. [b]That is, turned 17 years during Year 12. [c]Denotes a change through time.

Table 6.2

Participation in Enrichment and Extracurricular Science Activities and Positions of Interviews: Senior Girls

Activity	Year	Student				
		Abi	Angel	Rachel	Ruth	Wendy
Australian Science Competition	8				✓	
Australian Science Competition	9			C[a]	✓	
Investigation	9			✓	✓	
Museum Excursion	9			✓	✓	
Sciencentre Excursion	9			✓	✓	
Vacation Science Tour	9			✓	✓	
A.S.I.A. School	10				✓	
Evening Science (Tom Kirkpatrick)[b]	10				✓	
Australian Science Competition	10			D	✓	
National Chemistry Quiz	10 (July)			HD	✓	
				Int 1[c]	Int 1	
Primary Interface	10 (Sem. 2)			✓	✓	
Vacation Science Tour	10 (Sem. 2)			✓	✓	
Evening Science (Sid Miller)	11 (Term 1)			✓		
Australian Science Competition	11 (June)	✓	✓	D	✓	✓
Qld. Geology Competition	11 (July)	✓	✓	C	✓	✓
National Chemistry Quiz	11 (July)	✓	HD	HD		✓
R.A.C.I. Lecture	11 (August)	✓		✓		✓
Work Experience[d]	11 (Term 3)				✓	✓
Biology Olympiads	11 (Term 4)			✓		
Evening Science					1[e]	
		Int1	Int 1	Int 2	Int 2	Int 1
Vacation Science Tour	11 (Dec.)			✓	✓	

Table 6.2 (con't)

Activity	Year	Student				
		Abi	Angel	Rachel	Ruth	Wendy
CSIROSEC Excursion	12 (Term 1)		✓	✓		✓
Work Experience	12			✓(twice)		
Australian Science Competition	12 (June)	C	✓	C	✓	✓
Biology Investigation	12 (Term 3)	✓		✓	✓	✓
National Chemistry Quiz	12 (July)	✓	D	HD	✓	✓
Youth Physics Lecture	12 (Aug.)		✓	✓		✓
Physics Investigation	12 (Terms 2, 3)		✓	✓		✓
Chemistry Investigation	12 (Term 3)	✓	✓	✓	✓	✓
Science Club	12		⅓ of yr	⅔ of yr		All year
		Int 2	Int 2	Int 3	Int 3	Int 2

[a]Where an award was received, the type of award is indicated. The significance of each award is elaborated in Appendix 3A. [b]An *Evening Science with a Guest* activity. [c]Denotes first interview. [d]Only included if in a science-related area. [e]Indicates number of attendances during the year.

Table 6.3
Interest and Enjoyment in Being Involved in Science Activities: Senior Girls

Data technique	Student				
	Abi	Angel	Rachel	Ruth	Wendy
Rating scale					
Yr. 10	-	-	9.0, 8.0	9.0, 8.0	-
Yr. 11	8.0 (May), 6.0, 6.0	5.0 (March), 6.0, 5.0	7.0, 8.0	8.0, 8.0	8.0 (March), 7.0, 8.0
Yr. 12	8.0, 9.0	6.0, 5.0	8.0, 8.0	5.0, 6.0	8.0, 7.5
TOSRA(E) Enjoyment					
Yr. 10	-	-	8.6	9.0	-
Yr. 11	7.4 (May), 7.6	6.6 (March), 6.4	7.8	9.4	7.6 (March), 7.6
Yr. 12	7.6	6.0	7.4	9.0	6.8
TOSRA(L) Leisure					
Yr. 10	-	-	8.2	8.4	-
Yr. 11	6.8 (May), 7.4	5.6 (March), 6.4	8.6	7.0	7.2 (March), 6.6
Yr. 12	6.8	6.8	7.4	7.2	5.8
Course interest[a]					
Yr. 10	-	-	8.8	7.2	-
Yr. 11	6.0 (May), 6.2	5.6 (March), 6.8	7.6	9.8	6.8 (March), 7.0
Yr. 12	7.1	6.0	7.6	8.0	6.0

[a]Scores for the *Course Interest* survey in Years 11 and 12 represent the arithmetic average of the scores for a student from the surveys completed for each senior science subject the student was enrolled in at the time.

Table 6.4
Motivation to Continue to Participate in Science: Senior Girls

Data technique	Student				
	Abi	Angel	Rachel	Ruth	Wendy
Rating scale					
Yr. 10	-	-	10.0, 10.0	9.0, 7.0	-
Yr. 11	6.0 (May), 7.0, 10.0	5.0 (March), 5.0, 4.0	10.0, 10.0	8.0, 9.0	9.0 (March), 9.0, 7.0
Yr. 12	10.0, 10.0	5.0, 5.0	10.0, 10.0	2.5, 7.5	7.0, 7.5
TOSRA(C) Career					
Yr. 10	-	-	9.4	9.8	-
Yr. 11	6.4 (May), 6.8	5.2 (March), 5.2	9.0	8.8	7.0 (March), 7.6
Yr. 12	6.2	4.8	7.2	9.6	6.6

Table 6.5
Perceptions About Scientists: Senior Girls

Data technique	Student				
	Abi	Angel	Rachel	Ruth	Wendy
TOSRA(N) Normality					
Yr. 10	-	-	8.2	8.2	-
Yr. 11	6.6 (May), 6.2	7.4 (March), 6.0	8.0	8.4	6.0 (March), 7.8
Yr. 12	6.6	6.2	8.2	9.0	6.4

Table 6.6
Perceptions About the Role of Science in Society: Senior Girls

Data technique	Student				
	Abi	Angel	Rachel	Ruth	Wendy
Rating scale					
Yr. 10	-	-	8.0, 9.0	9.0, 9.8	-
Yr. 11	10.0 (May), 9.0, 9.0	6.0 (March), 8.0, 8.0	8.0, 8.0	9.0, 10.0	9.0 (March), 8.0, 9.0
Yr. 12	10.0, 10.0	8.0, 8.0	8.0, 8.0	9.5, 9.5	9.0, 8.0
TOSRA(S) Society					
Yr. 10	-	-	8.2	9.4	-
Yr. 11	8.2 (May), 7.2	8.6 (March), 6.2	8.2	9.2	7.8 (March), 8.4
Yr. 12	7.6	7.6	8.4	9.6	8.0

6.3 Case Studies: Senior Girls

While the primary focus on senior sample students in this thesis is the influence of science activities during Years 10 to 12, interview data were also collected from these students about science activities in which they participated during their earlier years of schooling. It was thought that this data could complement that for the junior sample students and hence further inform the research questions, especially in the case of senior students who had experienced science activities at Glendale College during their junior years which were identical, or similar, to those experienced by junior sample students.

Abi

Abi came to Glendale College as a boarding student at the beginning of Year 11. She studied Senior Biology and Chemistry with B/C ratings for achievement and very high effort and conduct and cooperation. Abi participated in five enrichment and three extracurricular activities.

Interest and enjoyment. Abi said during interview that during Year 10 (at her previous school) work experience with a veterinary surgeon increased her interest and enjoyment in being involved in science activities because she enjoyed working with the animals and it was "interesting to know that science built up to working with the animals." Contrary to the constant high levels shown in Figure 6.1a, Abi also said that her interest and enjoyment had increased from Year 10 to Year 11 as a result of coursework becoming more detailed and seeing the applicability of the coursework to everyday situations. Because "it was made fun and really interesting and just saw some really good things" (e.g. a substance with the properties of both a solid and a liquid), the R.A.C.I. Lecture also made a very strong positive contribution.

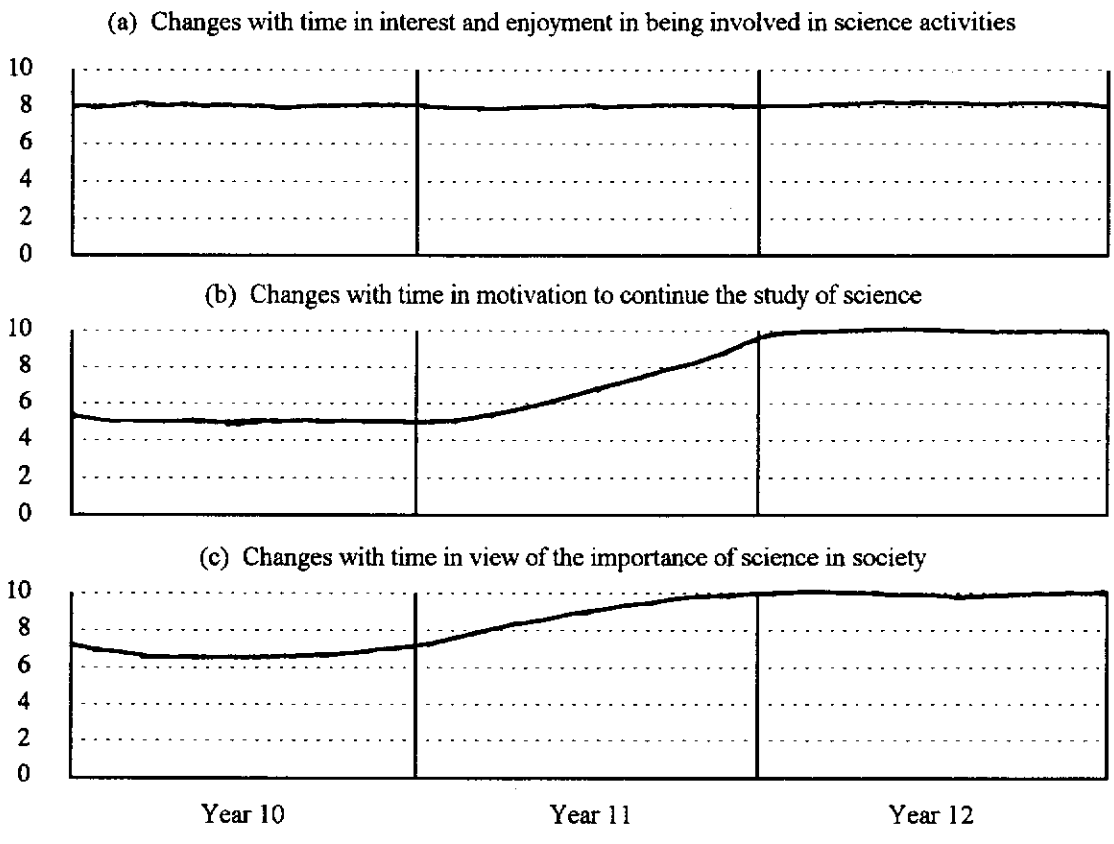

Figure 6.1. Graphs of retrospective trends: Abi.

During Year 12, she said both the Biology Investigation (because she enjoyed this work in which she was interested and about which she was curious) and the

Chemistry Investigation (because it was interesting, was her own experimental design, she was curious about the topic, and she enjoyed practical work more than theory) increased her interest and enjoyment, and the increase in Rating Scale and Course Interest scores in Table 6.3 support this.

In her final interview Abi said that Work Experience and a Marine Studies Excursion (both in her previous school) and the R.A.C.I. Chemistry Lecture were still having a positive effect in this domain.

Motivation. Abi's motivation increased to a very high level during the study period (Figure 6.1b and Table 6.4). During Year 10 (at her previous school) Abi had the desire to pursue a career in veterinary science, and she said that work experience in that area significantly increased her motivation to continue to participate in science.

During Year 11 she changed her career goal to fitness counselling (via an Applied Science Course in Human Movements) after discarding physiotherapy on the grounds that her tertiary entrance score would not be sufficiently high to gain entry. She said the adoption of this goal was the main reason for the marked increase in her motivation shown in Figure 6.1b, although the R.A.C.I. Chemistry Lecture (because she found it interesting) and the fact that she came to realise that science formed the basis for future study in a broad range of fields both made positive contributions.

In contrast, after doing the Queensland Geology Competition she concluded that she "didn't want to go into geology" because it "put me off with all the words they used . . . it didn't make me feel very smart, that's for sure," adding that the competition would be more worthwhile if the format was changed to test the ability of students to process questions, as required in the Australian Schools Science Competition.

During Year 12, following further research of tertiary courses and consideration of her interest and aptitudes, Abi said: "I've made a definite decision on what I want to do [speech therapy] and I know that it does require science pre-requisites . . . and to get my final goal of my career I'm highly motivated to study science." She said this increased assuredness in regard to her future goal further increased her motivation between Year 11 and Year 12.

During interview at the end of Year 12 she said that the R.A.C.I. Chemistry Lecture, Work Experience, and the Marine Studies Excursion were still having positive effects on her motivation because they all "widened my ideas of science." Abi subsequently enrolled in a Bachelor of Arts degree course and not speech therapy.

Scientists. Abi's perception of scientists remained unchanged during her senior years, although this perception consisted of two distinctly different images. She said that the first image that came to mind when someone mentioned the word *scientist* was a male, wearing glasses and a laboratory coat, doing research in a laboratory. "It's like if you were illustrating a children's book and you were doing a scientist, that's how you would portray them."

However, she also said that when she thought about it, this image did not fit and an image of a scientist as a normal, everyday person was more appropriate. Work Experience with a veterinary surgeon reinforced her perception of the normality of scientists (given that she regarded a veterinary surgeon to be a scientist).

Science in Society. Abi's view of the importance of science in society increased to a very high level during the study period (Figure 6.1c and Table 6.6). She said that Work Experience (veterinary science) in Year 10 showed her the everyday application of science in society ("it brought it [science] really down to earth") and that her view of the importance of science in society progressively increased during her senior years.

During interview at the end of Year 11 she said "science is life . . . everything is science really, some sort of science, it's the future [in terms of the problem-solving role of science]" and this view still applied at the end of Year 12.

She said coursework topics (e.g. genetic engineering in biology), research into the nature of tertiary courses and their prerequisites, and the media all contributed to her increasing view of the importance of science in society during her senior years. She also said that the Australian Schools Science Competition broadened her view of the role of science in society by including a question involving the issue of smoking, an area she had previously not pictured as being significantly linked with science.

Summary. A summary of the data for Abi is given in Table 6.7.

Table 6.7
A Summary of the Data for Abi

Variable	Overall trend	Contribution		Longer-term effects
		Positive	Negative	
Interest and enjoyment	Increase	R.A.C.I. Lecture, Biol. Investigation, Chem. Investigation, coursework (Work Experience, Marine Studies Excursion)[a]		R.A.C.I. Lecture (Work Experience, Marine Studies Excursion)
Motivation	Increase	R.A.C.I. Lecture, future goal (Work Experience)	Geol.Comp.	R.A.C.I. Lecture (Work Experience, Marine Studies Excursion)
Perceptions about scientists		(Work experience)		
Role of science in society	Increase	Coursework, Aust. Science Comp., tertiary course prerequisites, media (Work Experience)		

[a]Activities in brackets are those in a previous school.

Angel

Angel, a student from Hong Kong who was 2 years older than her peers, also came to the school as a boarder in Year 11. She studied Senior Chemistry and Physics, with A/B levels of achievement (although she received an atypical D^{+} for Physics in Year 12, Semester 2) and very high ratings for effort and conduct and cooperation. Angel participated in five enrichment and three extracurricular activities, notably receiving a High Distinction and a Distinction in the National Chemistry Quiz in Years 11 and 12, respectively.

Interest and enjoyment. As reflected in Figure 6.2a and the data of Table 6.3, Angel said that her interest and enjoyment in being involved in science activities remained constant during her senior years. However, she also said that the National

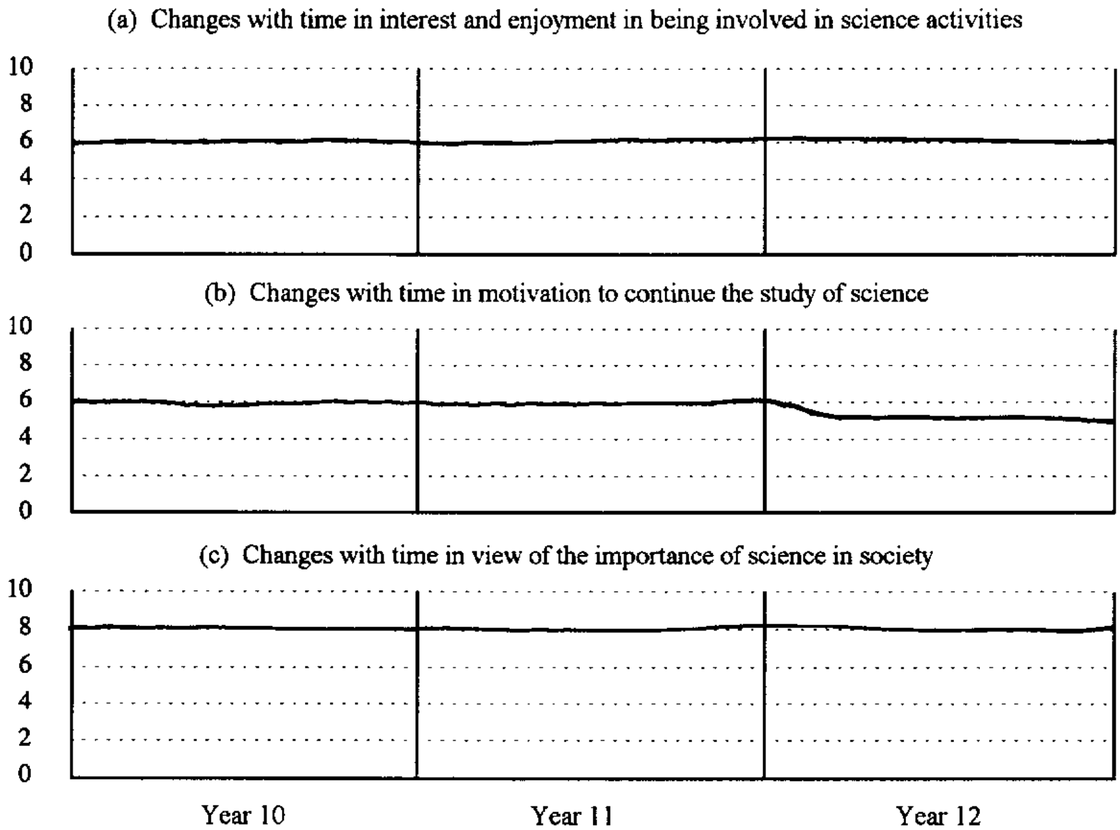

Figure 6.2. Graphs of retrospective trends: Angel.

Chemistry Quiz in Year 11 did increase her interest and enjoyment a little because she found it interesting and being rewarded with a High Distinction made her feel happy because it showed that she knew more than most others.

Motivation. Angel's motivation to continue to participate in science decreased during her senior years (Figure 6.2b). During Year 11 Angel had a career in interior design in mind. She said that obtaining a high distinction in the National Chemistry Quiz increased her motivation to continue to participate in science a little but that, as shown by the sharp decline in Figure 6.2b, the increased difficulty she found with chemistry and physics coursework in Year 12 compared with previous years decreased her motivation.

At the end of Year 12 Angel had changed her future career goal to the area of fine arts. Her post-Year 12 choices are not known as no reply was received to a letter asking what she was doing.

Scientists. Angel said that her view of a scientist as being an intelligent person of either sex who had the potential to change the quality of human lives remained unchanged during her senior years.

Science in society. During interview at the end of Year 11 Angel said that she considered science to play an important role in the lives of people, giving the contribution of science to the prevention of skin cancer as an example. Contrary to the high constant trend shown in Figure 6.2c, but in accord with the increase in Rating Scale score from 6.0 to 8.0 in Table 6.6, she also said that her view of the importance of science in society had increased a little during Year 11, giving as reasons her perception that world problems had increased (e.g. thinning of ozone layer) and that the improved global communications made possible by inventions such as television were responsible for our increased awareness of happenings around the world. Angel could not identify any source of her change in perception.

At the end of Year 12 she said that her earlier views about the role of science in society still applied, adding that she felt that everything was based on science, giving as an example the fact that fine art uses computers for design and that science was needed to make computers.

Summary. Table 6.8 summarises the data for Angel.

Table 6.8
A Summary of the Data for Angel

Variable	Overall trend	Contribution		Longer-term effects
		Positive	Negative	
Interest and enjoyment	No change	Nat. Chem. Quiz (Yr. 11)		
Motivation	Decrease	Nat. Chem. Quiz (Yr. 11)	Coursework difficult	
Perceptions about scientists				
Role of science in society	Increase			

Rachel

Rachel entered the school as a day student in Term 2, Year 9. She studied Biology, Chemistry, and Physics during her senior years, all at an A level of achievement and with very high ratings for effort and conduct and cooperation. During Year 9 she participated in four enrichment and one extracurricular activity and, during Years 10-12, eight enrichment and 13 extracurricular activities. Notable awards were a Distinction in the Australian Schools Science Competition in Year 10 and a High Distinction in the National Chemistry Quiz in each of Years 10, 11, and 12.

Interest and enjoyment. Rachel said during her Year 10 interview that four activities increased her interest and enjoyment in being involved in science activities during her junior years. She really enjoyed both the Year 9 and 10 Vacation Science Tours, saying that the former exemplified what she could aim for and illustrated many practical applications of science. She said that the behind-the-scenes look at the preserved specimens and classification schemes had a major positive effect on her interest and enjoyment. She described the latter as being like "miniature work experience," demonstrating both how science is applied and the working conditions of those involved and providing the opportunity to assess how closely she identified with such. She found the *Sciencentre* visit interesting and fun and it made her "want to become more involved in practicals in class." She said that she found her Year 9 Investigation, involving a telescopic study of heavenly bodies, interesting and enjoyable and that it showed her how one could achieve something scientific at home.

Rachel's interest and enjoyment increased to a high level in Year 11 (Figure 6.3a) as a result of the increased depth and breadth which the study of three separate sciences, as opposed to Junior Science alone, offered. Rachel also said during her Year 11 interview that Evening Science with Sid Miller increased her interest and enjoyment. "I've been interested in veterinary science and . . . Dr Miller's experience was pretty weird, in all the places that he'd been to and all the things he'd done so it just show [sic] you, um, the diverseness of the field, how you can splinter off into different directions and how interesting some of those were."

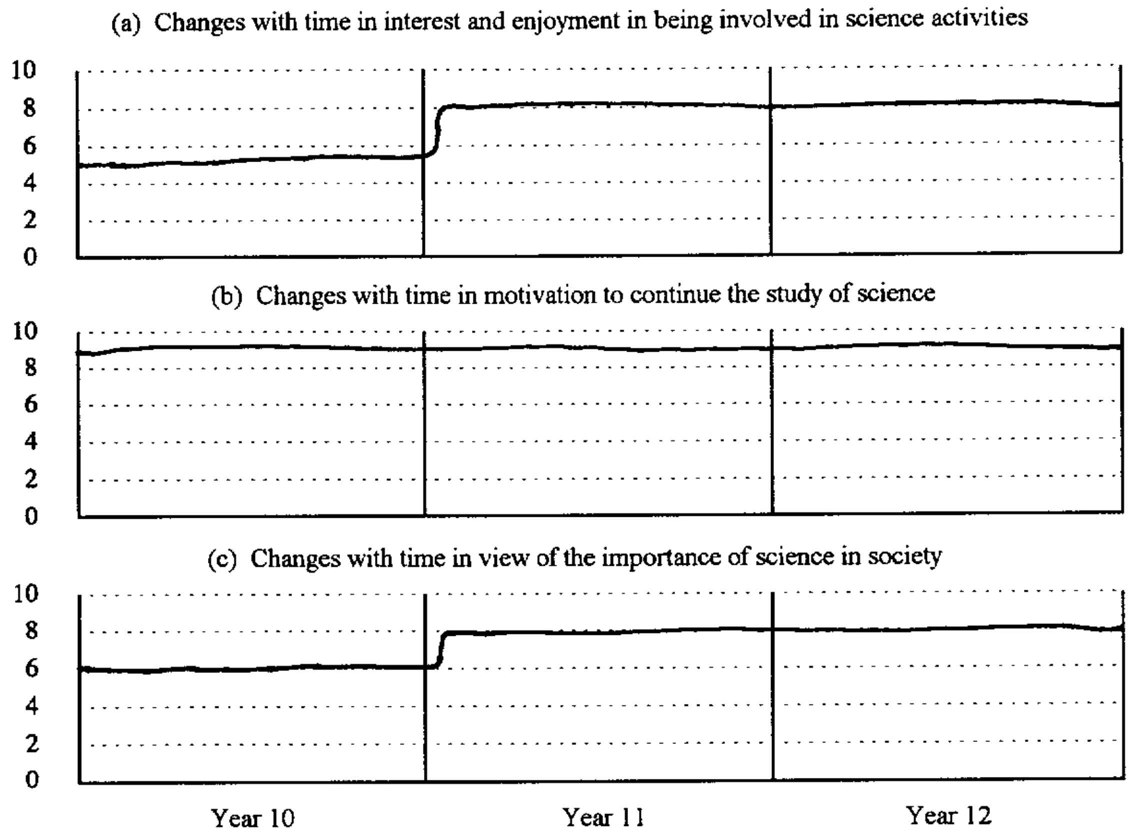

Figure 6.3. Graphs of retrospective trends: Rachel

Motivation. Rachel said that, during her junior years, the following activities increased her motivation to continue to participate in science: the Australian Schools Science Competition in Year 10 (because the award of a Distinction showed her that she could achieve something in science and that, compared with other students, she was good at science), the Vacation Science Tours in both Years 9 and 10 (because the work shown during the former was interesting and the latter, in addition to broadening her awareness of tertiary course and career opportunities, reinforced her already high motivation), the visit to the Museum (because she had always found palaeontology and anthropology interesting and seeing displays in these areas motivated her to get involved in these areas), and her Year 9 Investigation (because she found it interesting and it showed her that science was interesting). At the end of Year 10 Rachel had a science-based career in mind. Her parents had "sworn me off doing medicine or dentistry" (the respective careers of her parents) and, given her interest in animals, she was interested in pursuing veterinary science or some kind of biological research.

Rachel's motivation was always high during the study period (all Rating Scale scores of 10 out of 10 in Table 6.4). She said that, during Year 11, Evening Science with Sid Miller reinforced her desire to study veterinary science and that, as a result of again achieving highly in the National Chemistry Quiz, she was not only motivated to continue to participate in science, but also now considered the study of chemistry at the tertiary level to be an option.

Contrary to the constant trend shown in Figure 6.3b, Rachel said that her motivation increased from Year 11 to Year 12 because "as I've gotten closer and closer to university my options have sort of narrowed down and I've become more sure of what I've had to do so, science or nothing." She also said that while Work Experience with a veterinary surgeon reaffirmed her desire to study veterinary science, Work Experience in a biochemistry laboratory had a large motivating effect. The latter had the effect of showing her that studies in biochemistry would be interesting and opened up another potential tertiary study option.

Towards the end of Year 12 Rachel also had tertiary courses in molecular biology or medicine in mind, saying that the latter would need to be in the specialist, surgical, or university areas as opposed to the general practice of her mother. She subsequently enrolled in a Bachelor of Veterinary Science course.

Scientists. During her Year 10 interview Rachel described a scientist as a person with an aptitude for, interest in, curiosity about, and who achieved a lot in, what she perceived to be an interesting job. She said that "no real stereotype like the mad scientist" came to mind, that gender was not an issue, and that whether they wore a labcoat depended upon whether they were working in a laboratory or out scuba-diving. She also said that this perception remained with her during her senior years, and the scores in Table 6.5 support this.

She said that the Vacation Science Tour in Year 9 and the visit to the museum both broadened her view of the type of work in which scientists were engaged (cataloguing of preserved specimens and the preparation of materials aimed at teaching rather than research and development, respectively) and that the biochemistry Work Experience reinforced her view of the normality of scientists and showed her that their research-oriented lifestyle seemed interesting.

Science in society. During her Year 10 interview Rachel said that "science has taken over from superstitions and religions in quite a large way . . . . Everything we do has something to do with science work because it's come from a scientific discovery which has led to a practical application" and that there were two main functions of science: "finding out about the world and how it runs so we don't destroy it" and "improving it [the world] by helping people and helping animals and environments and new inventions and things."

She said that by highlighting the closeness of science to practical applications that change society (e.g. the link between mining and world economics), the Vacation Science Tour in Year 9 reinforced her view of the importance of science in society. Without the tour "it wouldn't seem as though the research would have much connection with real life."

Rachel said that her Year 10 perception remained with her during her senior years, with the increase in her view of the importance of science in society to a high level shown in Figure 6.3c being a result of her increased awareness of different applications of science due to the greater depth and breadth of coverage of science topics in her senior subjects compared with Junior Science.

Summary. A summary of the data for Rachel is given in Table 6.9.

Ruth

Ruth began at Glendale College as a boarder in Year 8. During Years 8 and 9 she participated in five enrichment activities and one extracurricular activity. During her senior years she studied Biology and Chemistry (and Physics for one semester only) with her achievement decreasing from a B to C/D level but with very high effort and conduct and cooperation ratings at all times. During Years 10 - 12, Ruth participated in four enrichment activities and 12 extracurricular activities.

Interest and enjoyment. Ruth said that, during her junior years, the following activities increased her interest and enjoyment in being involved in science activities: the *Sciencentre* visit (because the activities were varied, fun, and interesting), her Year 9 Investigation involving gold extraction techniques (because she found it interesting and the people she met enjoyed their work), the Year 9 and 10 Vacation Science Tours (because the former was interesting, broadened her perception of the

Table 6.9
A Summary of the Data for Rachel

Variable	Overall trend	Contribution		Longer-term effects
		Positive	Negative	
Interest and enjoyment	Increase	Vacation Tour (Yr. 9, 10), *Sciencentre*, Investigation, coursework, Sid Miller		
Motivation	Increase	Aust. Sc. Comp. (Yr. 10), Vacation Tour (Yr. 9, 10), Museum, Investigation (Yr. 9), Sid Miller, Nat. Chem. Quiz (Yr. 10, 11), Work Experience (vet, biochem)		
Perceptions about scientists		Vacation Tour (Yr. 9), Museum, Work Experience (biochem)		
Role of science in society	Increase	Coursework, Vacation Tour (Yr. 9)		

avenues that science studies can lead to, and the personnel conveyed an enjoyment in what they were doing, and the latter because she found it interesting to see finally what forensic science involved), the A.S.I.A. Science Summer School (because it was fun, and educational), and the National Chemistry Quiz (because she found it interesting and enjoyed trying to solve the questions). To a lesser extent, the Year 10 - Primary Interface also contributed positively, because she enjoyed doing it and observed that the primary students enjoyed it.

The "more specific" nature of the separate sciences in Year 11 further increased her interest and enjoyment, as did Work Experience in forensic science, because she found it enjoyable and the personnel helpful if she showed an interest. The Year 9 and Year 10 Vacation Science Tours were still having a positive effect in Year 11.

As reflected in Figure 6.4a and the decrease in Rating Scale score from 8.0 to about 5.5 in Table 6.3, the increase in difficulty which Ruth experienced in studying

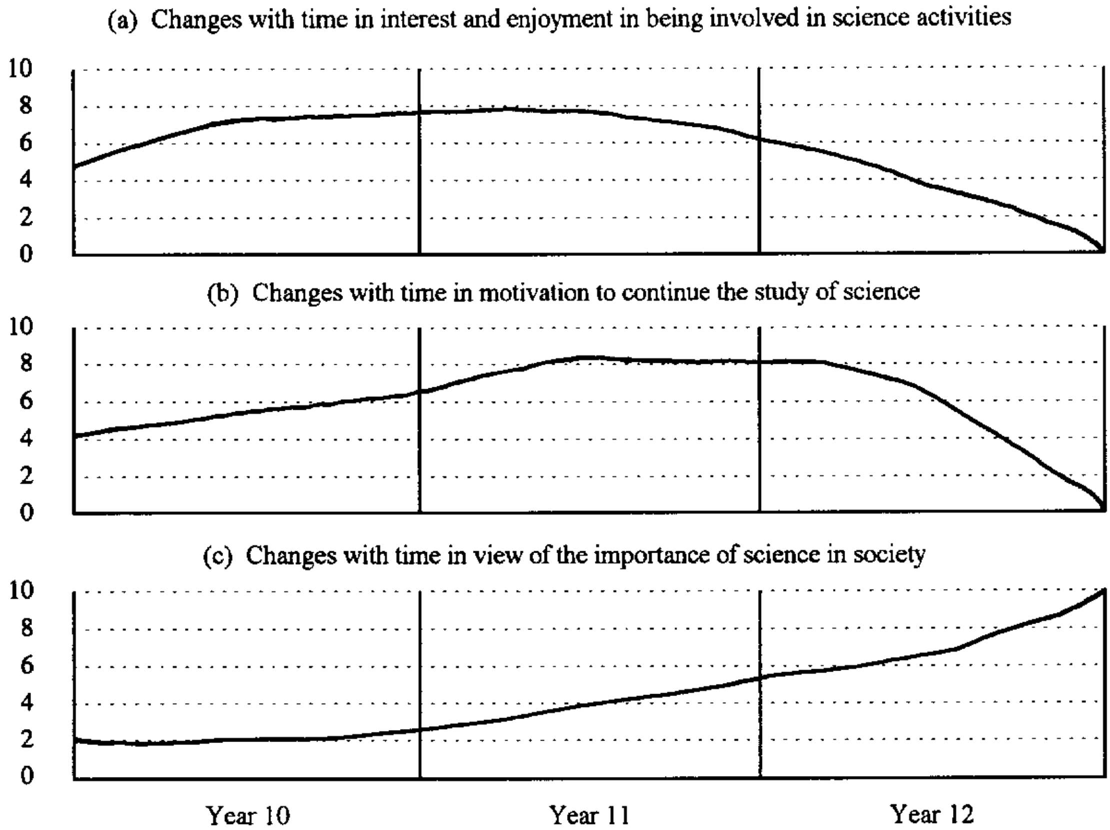

Figure 6.4. Graphs of retrospective trends: Ruth.

her senior sciences during Year 12 decreased her interest and enjoyment to a low level. "I can study for hours and hours and still not pass the subject . . . and that really does bring the interest in science . . . down." She recognised that her achievement was higher in the humanity subjects. However, Ruth said that her Chemistry Investigation did increase her interest and enjoyment a little because she enjoyed "doing something I wanted to do."

Motivation. Ruth said that, during her junior years, the following activities increased her motivation to continue to participate in science: the *Sciencentre* (because the variety of exhibits broadened her perception of the scope of scientific endeavour and led her to conclude that "you can do anything [in science]"), her Year 9 Investigation (because she enjoyed it very much and it showed her that science can be interesting "if you get the right thing to do"), the Year 9 and 10 Vacation Science Tours (because they were interesting, broadened her view of what science studies can lead to, gave her the message "basically, try and do all sciences," reinforced her desire to pursue a career in forensic science, and, because of the variety of science fields covered, led her to believe that competition to enter may not be as great as in other areas where all compete for the same type of work), the A.S.I.A. Science Summer School (because it was enjoyable, fun, involved caring personnel, and gave her the desire to do all three senior science subjects, a desire which she said she may otherwise not have had), and the National Chemistry Quiz (because she learnt about the properties, and reactions, of different chemicals). To a lesser extent, the Year 10-Primary Interface also had a positive effect on her motivation as it further broadened her perception of what science could involve. At the end of Year 10 Ruth had the desire to pursue a career in forensic science.

During Year 11, Work Experience in forensic science (because it reinforced her desire to study forensics) and, to a lesser extent, the Queensland Geology Competition (because, even though she didn't understand many of the quesitons, it made her aware that geology, in which she was interested, was another post-secondary option) had positive effects on Ruth's motivation, while Evening Science had a slight negative effect ("because even when you get help [with physics problems] you can't do it and it makes you feel degraded, stupid, dumb"). She dropped Physics during second semester because she felt she could not master the concepts. At the end of Year 11 Ruth still had forensic science as a career goal but was also researching other fields such as law. The Year 9 and 10 Vacation Science Tours were still having a positive effect on her motivation at this time.

As shown in Figure 6.4b, Ruth's motivation decreased to a low level during Year 12. She said this was because her interest and enjoyment had dropped as a result of finding her science subjects difficult. Her Chemistry Investigation did, however, have a very strong motivating effect on her because she had success with a forensic test which she had seen demonstrated during Work Experience and this kept the "flame" for forensics alive. Work Experience was still having a positive effect on her motivation at the end of Year 12 and, although she was still interested in forensics, she realised that she could enter via another degree. By this time her tertiary thoughts had changed to agricultural economics, law, economics, or justice studies and Ruth subsequently enrolled in a Bachelor of Agricultural Economics course.

Scientists. Ruth's perception of scientists early in her junior years was rather stereotypical, including a white lab coat and glasses image. She said that the Year 9 Vacation Science Tour (where different kinds of friendly and helpful people were enjoying doing different things), Evening Science with Tom Kirkpatrick ("They [scientists] don't have to be . . . square people that just sort of stick to their work. They can be anybody."), and the A.S.I.A. Science Summer School ("[scientists] can be any kind of people, anybody can do it . . . they're sort of all different people") showed her that such a stereotype does not apply. She also said that the Australian Science Competitions broadened her view of the different types of work in which scientists can engage and that the Year 10-Primary Interface, because most of the demonstrations were chemically-based, led her to believe that scientists deal with many different chemicals. At the end of Year 10, in addition to the above, her perception of scientists included hard-working achievers striving to discover or prove something new who were generally nice people of either sex who enjoyed helping, and communicating their work to, other people.

Ruth said that Work Experience during Year 11 reinforced the inappropriateness of a stereotypical image because personnel exhibited many different attitudes to work (including commitment) and life. At the end of Year 12 she said that, as a result of science coursework (e.g. genetic engineering), "I seem to recognise them [scientists] more, they're everywhere."

Science in society. Ruth said that the following activities broadened her perception about the role of science in society during her junior years: the *Sciencentre* visit (which demonstrated how some concepts can be applied in a recreational context), the Vacation Science Tours in Years 9 and 10 (e.g. arson and the law), and the National Chemistry Quiz (which showed her unfamiliar ways, such as use in fertilisers, in which chemicals were used in society). She also said that, as a result of her Year 9 Investigation, she concluded that the community perception of dangerous aspects associated with mining (such as cyanide overflow) was unfounded, given that the required scientific research had already been done and that, by introducing scientific laws and highlighting their application to society, the A.S.I.A. Science Summer School increased her view of the importance of science in society.

At the end of Year 10 Ruth said that science played a very important role in society, as reflected in the scores of Table 6.6. She also said that science develops new ways of killing people (including more quickly) and that although it would be better if people could get along with one another and research efforts instead be diverted to areas such as curing diseases, in practice this doesn't happen.

As shown in Figure 6.4c, Ruth's view of the importance of science in society increased to a very high level during her senior years. She said that this was a result of Work Experience (which demonstrated how evidence such as hair and fingerprints were used in court), coursework in both chemistry and biology (e.g. blue-green algae, evolution, foetal screening, and genetic engineering), newspaper articles, and television. During this time she became more aware of the work being done towards curing diseases.

Summary. Table 6.10 summarises the data for Ruth.

Wendy

Wendy entered the college as a boarder in Year 11. She studied Biology, Chemistry, and Physics during her senior years with C/D levels of achievement and very high ratings for effort and conduct and cooperation. Wendy participated in eight enrichment science activities and five extracurricular activities.

Interest and enjoyment. Contrary to the constant level shown in Figure 6.5a, Wendy said that there were three influences that increased her interest and enjoyment in being involved in science activities during Years 10 to 12: the splitting of science into three disciplines in Year 11 (which made science more interesting), the R.A.C.I. Chemistry Lecture (because it showed her areas of science [polymers and examples of the manufacturing of new substances] which she found very interesting and of which she was previously unaware), and, more significantly, Work Experience in radiography (because of the technology and variation, such as no two breaks being the same, involved). Work Experience was still having a positive effect on her interest and enjoyment towards the end of Year 12.

Table 6.10
A Summary of the Data for Ruth

Variable	Overall trend	Contribution		Longer-term effects
		Positive	Negative	
Interest and enjoyment	Decrease	*Sciencentre*, Investigation, Vacation Tour (Yr. 9, 10), A.S.I.A. School, Nat. Chem. Quiz (Yr. 10), Primary Interface, coursework, Work Experience, Chemistry Investigation	Coursework difficult	Vacation Tour (Yr. 9, 10)
Motivation	Decrease	Nat. Chem. Quiz (Yr. 10), Vacation Tour (Yr. 9, 10), *Sciencentre*, Investigation, A.S.I.A. School, Primary Interface, Work Experience, Qld. Geol. Comp., Chem. Investigation	Evening Science, coursework	Vacation Tour (Yr. 9, 10), Work Experience
Perceptions about scientists		Vacation Science Tour (Yr. 9), Tom Kirkpatrick, A.S.I.A. School, Aust. Science Comps. (Junior), Primary Interface, Work Experience, coursework		
Role of science in society	Increase	A.S.I.A. School, Work Experience, coursework, newspapers, television, *Sciencentre*, Vacation Tours (Yr. 9 ,10), Nat. Chem. Quiz, Investigation		

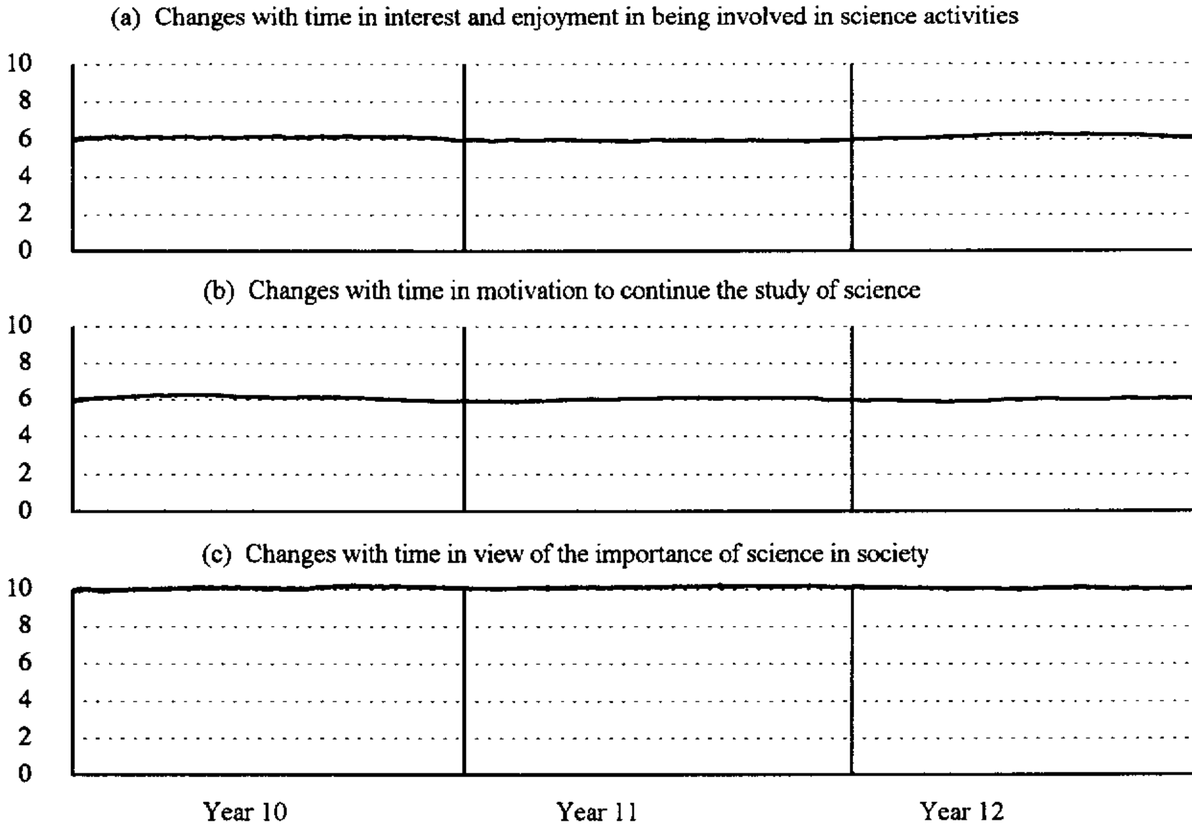

Figure 6.5. Graphs of retrospective trends: Wendy.

Motivation. Since about Year 6 or Year 7, Wendy had thought that she would like to pursue a career in the science area, and Pharmacy was uppermost in her mind in Year 10. Contrary to the uniform trend shown in Figure 6.5b, Wendy said that her motivation to continue to participate in science increased between Year 10 and Year 11 because the splitting of science into three separate subjects made science more interesting. In addition, four Year 11 activities had positive effects on her motivation. Of these, Work Experience had the greatest effect. She found radiography so interesting that applied science (which included radiography) replaced pharmacy as her career goal. Having smaller positive effects on her motivation were the Australian Schools Science Competition ("because . . . I hadn't covered most of that work and I obviously wanted to learn it so I could understand these sort of things"), the R.A.C.I. Chemistry Lecture (because it revealed the possible tertiary avenue of a Bachelor of Applied Science majoring in chemistry), and the National Chemistry Quiz (because, even though most of the terms used were new, she could still make sense of the questions and learning the meaning of these new terms motivated her).

Wendy also said that, although she had no real interest in geology beforehand, the difficulty of the Queensland Geology Competition "definitely made me not want to do geology." At the end of Year 11, in addition to radiography, Wendy also regarded teaching as a possible future occupation. By the end of Year 12 she confirmed that it was a tertiary course in a medical science (e.g. radiography, pharmacy, clinical techniques) that she sought and that Work Experience was still having a very strong effect in motivating her to enter radiography. She subsequently enrolled in an Associate Degree in Clinical Techniques (which does not include radiography).

Scientists. During her end-of-Year 11 interview Wendy described scientists as "basically normal people, they're just um, got an interest in science. They're not eccentric people like everyone thinks they are." She said that she had this view during Year 10 also, and subsequently said that this perception did not change during Year 12.

Science in society. As Figure 6.5c and the Rating Scale scores in Table 6.6 show, Wendy rated the importance of science in society very highly during Years 10 to 12. She said that during Year 11, the following three activities positively affected her perception of the role of science in society: the Australian Schools Science Competition (because it included areas of science, such as life issues and mining, which were shown to be used in society but of which she was previously unaware), the R.A.C.I. Chemistry Lecture (because it broadened her view in this area by demonstrating how polymers can be used to make bullet-proof screens), and Work Experience (where new technologies such as computer tomography and CAT scans were improving medical standards by, for example, reducing the pain otherwise suffered by someone while a broken arm is x-rayed).

At the end of Year 11 Wendy said that science is:

> going to be very big environmentally because of greenhouse and CFCs and the ozone and, and ah, also it's going to be a big thing in technology, improvement of lifestyles, medical ah cures to diseases they haven't found cures for yet,

and that she had this same view during Year 10. Wendy also said that her view of the importance of science in society increased between Year 11 and Year 12 as a result of the implications of genetic engineering for people's lives addressed during coursework.

Summary. A summary of the data for Wendy is given in Table 6.11.

Table 6.11
A Summary of the Data for Wendy

Variable	Overall trend	Contribution		Longer-term effects
		Positive	Negative	
Interest and enjoyment	Increase	Course structure, R.A.C.I. Lecture, Work Experience		Work Experience
Motivation	Increase	Course structure, Work Experience, Aust. Sc. Comp. (Yr. 11), R.A.C.I. Lecture, Nat. Chem. Quiz (Yr. 11)	Qld.Geol. Comp.	Work Experience
Perceptions about scientists				
Role of science in society	Increase	Aust. Sc. Comp. (Yr. 11), R.A.C.I. Lecture, Work Experience, coursework		

6.4 Background Information: Senior Boys

Biographical Details

Table 6.12 summarises the biographical details of the senior sample boys.

Table 6.12
Biographical Details: Senior Boys

Dimension	Student				
	Alec	Andrew	James	Luke	Scott
Status	Day student	Boarder	Day Student	Day student	Day student
Position in family	Second of three	Third of five	First of four	Second of three	Third of four
Parents' occupations	Businessman, library technician	Graziers	Teacher, nurse	Civil engineer, child health nurse	Farmer, physiotherapist
Age	Typical[a]	Typical	Typical	Typical	Typical
Entry to college	Year 7	Year 8	Year 11	Year 8	Year 8
Senior science subjects	Chemistry, Physics	Biology, Chemistry	Biology, Chemistry, Physics	Biology, Chemistry, Physics	Chemistry, Physics
Achievement	B	B→[b]C/D	C	A(some B's)	A/B
Effort	1/2	2/3→4[c]	2/3	1/2	1/2
Conduct and cooperation	1/2	1/2	1/2	1	1
Tertiary course	B.Sc./ B.App.Sc.	B.App.Sci. (Rural Management)	B.Sc.	B.App.Sci. (Optometry)	B.Physiotherapy

[a]That is, turned 17 years during Year 12. [b]Denotes a change through time. [c]Tardiness in submitting tasks and perceived underachievement were a concern of staff during senior years.

Participation in Activities

Table 6.13 summarises participation, in chronological order where appropriate, by senior sample boys in the enrichment and extracurricular science activities. Once again, only those activities experienced by sample students are listed and they do not include all activities offered.

Table 6.13
Participation in Enrichment and Extracurricular Science Activities and Positions of Interviews: Senior Boys

Activity	Year	Student				
		Alec	Andrew	James	Luke	Scott
Australian Science Competition	7	HD[a]				
Australian Science Competition	8	C	D		D	D
Australian Science Competition	9	D	C		D	HD
Investigation	9	✓	✓		State prize	✓
Museum Excursion	9	✓	✓		✓	✓
Sciencentre Excursion	9	✓	✓		✓	✓
Science Club	9	✓				
A.S.I.A. School	10	✓			✓	✓
Australian Science Competition	10	C	D		D	D
National Chemistry Quiz	10 (July)	D	C		D	HD
		Int 1[b]	Int 1		Int 1	Int 1
Primary Interface	10 (Sem. 2)	✓			✓	✓
Vacation Science Tour	10 (Sem. 2)	✓			✓	
Australian Science Competition	11 (June)	D	✓	✓	HD	D
Qld. Geology Competition	11 (July)	C	✓	C	C	

Table 6.13 (con't)

Activity	Year	Student				
		Alec	Andrew	James	Luke	Scott
National Chemistry Quiz	11 (July)	✓	C	C	C	D
R.A.C.I. Lecture	11 (August)	✓		✓	✓	✓
Work Experience[c]	11 (Term 3)		✓	✓		
Biology Olympiads	11 (Term 4)				✓	
		Int 2	Int 2	Int 1	Int 2	Int 2
Vacation Science Tour	11 (Dec.)	✓		✓	✓	
CSIROSEC Excursion	12 (Term 1)	✓		✓	✓	✓
Work Experience	12				✓	✓
Australian Science Competition	12 (June)	D	✓	C	D	D
Biology Investigation	12 (Term 3)		✓	✓	✓	
National Chemistry Quiz	12 (July)	D	✓	D	D	HD
Youth Physics Lecture	12 (Aug.)	✓		✓	✓	✓
Physics Investigation	12 (Terms 2, 3)	✓		✓	✓	✓
Chemistry Investigation	12 (Term 3)	✓	✓	✓	✓	✓
Science Club	12			⅓ of yr	⅔ of yr	⅓ of yr
		Int 3	Int 3	Int 2	Int 3	Int 3

[a]Where an award was received, the type of award is indicated. The criteria for awards are given in Appendix 3A. [b]Denotes first interview. [c]Only included if in a science-related area.

6.5 Some Quantitative Data: Senior Boys

Tables 6.14 to 6.17 report the quantitative data from each survey instrument administered, plus the Rating Scales completed during interviews where applicable, for each dependent variable. All scores given in the tables have again been converted to scores out of 10.

Table 6.14

Interest and Enjoyment in Being Involved in Science Activities: Senior Boys

Data technique	Student				
	Alec	Andrew	James	Luke	Scott
Rating scale					
Yr. 10	8.0, 8.5	7.0, 7.0	-	7.0, 7.5	5.0, 8.0
Yr. 11	5.0, 7.0	5.0, 7.0	8.0 (May)[a], 8.0, 8.0	7.5, 8.0	7.0, 7.0
Yr. 12	6.5, 7.0	4.0, 5.0	7.0, 8.0	8.0, 8.5	8.0, 8.0
TOSRA (E) Enjoyment					
Yr. 10	8.4	5.0	-	7.2	5.0
Yr. 11	5.8	4.2	8.0 (May), 7.6	6.4	6.2
Yr. 12	6.2	3.6	8.2	6.8	6.2
TOSRA (L) Leisure					
Yr. 10	7.6	5.2	-	6.0	6.2
Yr. 11	6.8	4.8	5.4 (May), 5.6	5.8	5.4
Yr. 12	6.0	4.6	7.8	5.4	4.8
Course interest[b]					
Yr. 10	7.6	4.8	-	5.8	4.4
Yr. 11	4.2	5.6	6.8 (May), 6.0	6.7	6.1
Yr. 12	5.0	4.3	6.7	6.0	6.6

[a]Dated scores in Tables 6.14 - 6.17 are data from surveys administered to James after his arrival at the school in Year 11. [b]Scores pertaining to the *Course Interest* survey in Years 11 and 12 represent the arithmetic average of the scores for a student from the surveys completed for each senior science subject in which the student was enrolled at the time.

Table 6.15
Motivation to Continue to Participate in Science: Senior Boys

Data technique	Student				
	Alec	Andrew	James	Luke	Scott
Rating scale					
Yr. 10	8.0, 8.0	7.0, 7.0	-	7.5, 6.0	7.0, 9.0
Yr. 11	5.0, 4.0	7.0, 7.0	9.0 (May), 8.0, 9.0	7.0, 9.0	7.0, 5.0
Yr. 12	9.0, 8.5	8.0, 7.0	9.0, 9.0	8.5, 8.0	8.0, 8.0
TOSRA (C) Career					
Yr. 10	6.8	6.2	-	7.6	6.2
Yr. 11	5.0	5.4	7.0 (May), 6.6	7.2	7.0
Yr. 12	6.4	4.6	8.0	7.4	6.6

Table 6.16
Perceptions About Scientists: Senior Boys

Data technique	Student				
	Alec	Andrew	James	Luke	Scott
TOSRA (N) Normality					
Yr. 10	9.4	5.8	-	7.2	8.0
Yr. 11	8.6	6.6	8.0 (May), 8.0	7.0	9.0
Yr. 12	8.6	6.6	8.0	7.6	8.0

Table 6.17
Perceptions About the Role of Science in Society: Senior Boys

Data technique	Student				
	Alec	Andrew	James	Luke	Scott
Rating scale					
Yr. 10	9.5, 9.0	7.0, 9.0	-	6.0, 7.0	8.0, 8.0
Yr. 11	9.0, 9.0	7.0, 8.0	9.0 (May), 9.0, 9.0	8.5, 9.0	8.0, 8.0
Yr. 12	8.0, 9.0	5.0, 6.0	8.0, 8.0	9.0, 8.5	7.5, 7.5
TOSRA (S) Society					
Yr. 10	9.4	6.8	-	7.6	7.2
Yr. 11	9.6	5.6	8.4 (May), 8.6	8.8	7.0
Yr. 12	8.6	7.4	8.2	8.4	7.4

6.6 Case Studies: Senior Boys

Alec

Alec entered Glendale College as a day student in Year 7. During Years 7 - 9, he participated in six enrichment activities and one extracurricular activity. He achieved at a B level in Chemistry and Physics during his senior years, with 1/2 ratings for effort and conduct and cooperation. During Years 10 - 12, Alec participated in eight enrichment science activities and eight extracurricular activities, obtaining a number of Distinctions in both the Australian Schools Science Competition (a High Distinction in Year 7) and the National Chemistry Quiz.

Interest and enjoyment. Alec's interest and enjoyment in being involved in science activities decreased and then increased back to its original level during the study period (Figure 6.6a and Table 6.14).

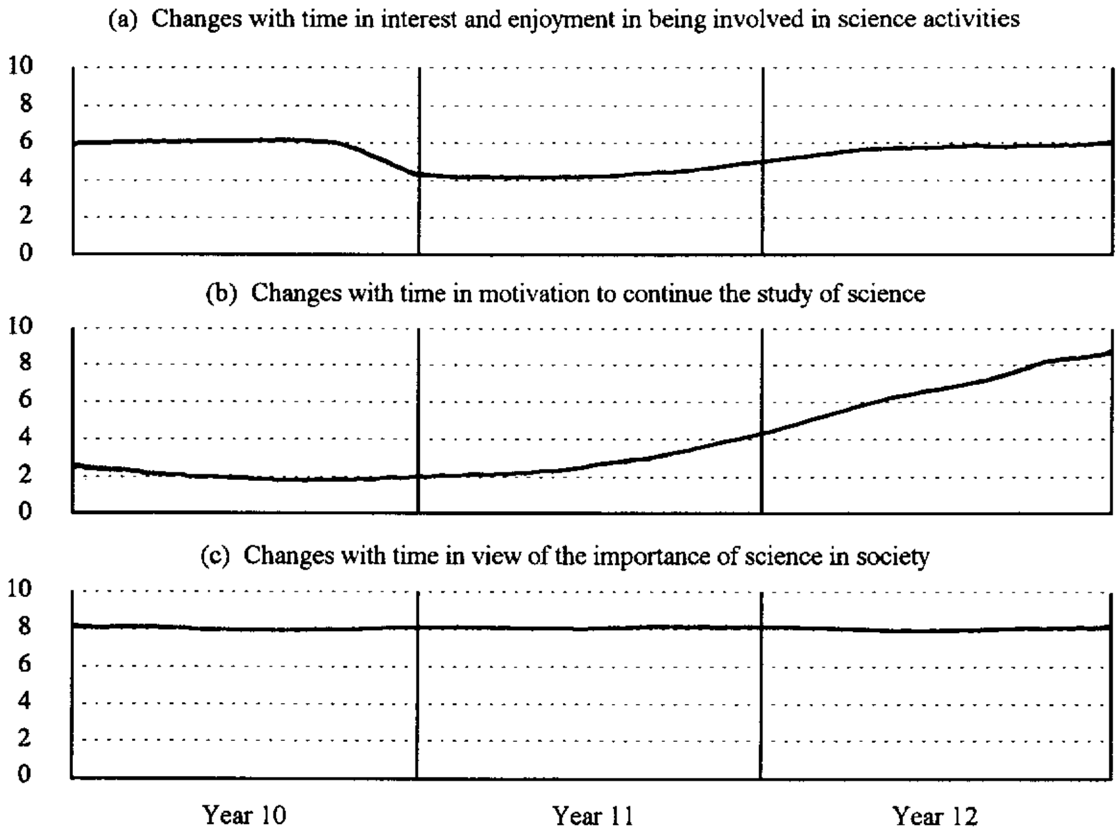

Figure 6.6. Graphs of retrospective trends: Alec.

According to Alec, there were four positive contributions to his interest and enjoyment during his junior years; the Australian Schools Science Competitions (because "I have done well in them or reasonably well [a high distinction, credit, distinction, and credit, respectively, during Years 7 to 10] so that makes me feel like I've accomplished something and that I can do the science subjects so it motivates me a bit more to go and study harder and longer"), the National Chemistry Quiz (being awarded a distinction gave him a sense of achievement and desire to continue to study chemistry), the *Sciencentre* visit (because it was hands-on, interesting, and "you could see or hear the results . . . . I could do something and then just work out what it was doing," even though he had visited with his parents some 6 to 9 months previously), and the A.S.I.A. Science Summer School because:

> it was just, well, the way they did it was fun and interesting, it showed me a lot of new things and it lent towards the, um, ah, a person going into a science career. It just showed me things I hadn't known and let me find something out in a way that made me think I discovered it. They just weren't

rattling on and telling me things. It's really interesting.

In particular, his participation in the Australian Schools Science Competition in Year 7 was having a lasting effect in Year 10 because "I went extremely well throughout the State."

In contrast, Alec's Year 9 Investigation had a "very little negative effect, maybe even a neutral effect" on his interest and enjoyment in being involved in science activities. His investigation was aimed at enabling disabled people to open containers like jars for which one typically needs hands or fingers.

> I don't think it was much help because of the fact it was always looming over me in Year 9 and there was almost a pain right at the end because it was such a big project and you got nervous and kept doing things wrong in it so, I didn't really like it . . . . I think it almost diminished from it [his interest and enjoyment in being involved in science activities] because . . . it was very intimidating if you didn't get it right . . . . It is hard to think of something to study or invent, so that's, that causes difficulty in the interest.

The relatively sharp decline in Alec's interest and enjoyment in being involved in science activities towards the end of Year 10 (Figure 6.6.a) was the result of him being annoyed that his classroom teacher was not prepared to make any adjustment to his achievement on the end-of-semester examination (the only exam to contribute to summative achievement during Semester 2) related to questions involving material which was covered in class during a 3-week period of hospitalisation.

Tending to dampen his interest and enjoyment during Year 11 was his perception that his achievement in chemistry and physics were not as high as he would have liked. However, the gradual increase in his interest and enjoyment during Year 11 was the result of him finding his senior science courses increasingly interesting, but with a relatively poor result on the end-of-year physics examination being responsible for a levelling out of this trend. At the same time, the *Sciencentre* visit 2 years earlier was still having a small positive effect on his interest and enjoyment in being involved in science activities.

Despite the slight increase in interest and enjoyment shown in Figure 6.6a in Year 12, Alec perceived, during interview, no real overall change, with contributions being linked to the demands of his science courses.

> It [interest and enjoyment] fluctuates depending upon whether or not I've got an investigation or report to hand in. When I do I sort of dislike the sciences more and more. But really I find them interesting.

While his chemistry investigation had a small positive effect on his interest and enjoyment, his physics investigation had a small negative effect. The former was aimed at either extracting the calcium from a given section of bone or calculating the weight of calcium as a percentage of the weight of the bone, and he found this a challenge and it gave him something to work towards. In contrast, he found his physics investigation annoying, boring, and repetitive. Here, he attempted to study the effect, on growth rate, of an electric current through bean plants and his frustration stemmed partly from the continual tampering with his experimental apparatus by other students. He regarded his results as "lousy."

Despite receiving distinctions in the Australian Schools Science Competition in both Years 11 and 12, these competitions had no effect on his interest and enjoyment. This was partly because he was used to getting such awards in this competition and partly because he set high expectations for himself, using a personal achievement rating system which he regarded to be somewhat different to that of many other students, and indeed College staff, in which he equated an A with *done well*, a B with *done o.k.*, and a C with *failed*, in contrast with the intended meanings of *done very well*, *done well*, and *satisfactory*, respectively.

Motivation. Alec's motivation to continue to participate in science during the study period also decreased and then increased to a high level (Figure 6.6b and his elaboration during interview), a trend shown clearly by the *Rating Scale* data in Table 6.15.

Alec's motivation during his junior years was positively influenced by the same activities which also increased his interest and enjoyment: the Australian Schools Science Competition and the National Chemistry Quiz (because of his successes in them; Alec obtained a distinction in the latter in Year 10), the A.S.I.A. Summer School (because "the developments or the experiments that we did in, um, their chemistry and or the electronics did interest me"), and the *Sciencentre* visit (because "of the, um, way in which it showed science. It made it more enjoyable"). However, had he not attended the A.S.I.A. Summer School and/or the *Sciencentre*, Alec said he would probably have still chosen chemistry and physics as senior subjects as these two activities "made me a bit more sure of my choices."

During Year 10 Alec was planning to study chemistry and physics during his senior years with a view towards a tertiary course in architecture; or perhaps civil engineering or psychology. During his third-round interview he reflected that, at the same time, the slight decrease in motivation shown in Figure 6.6b towards the end of Year 10 was due to his lack of interest in continuing to study science past Year 12.

During much of Year 11, Alec painted an overall picture of uncertainty as to his future direction and this coincided with the relatively low levels of motivation shown by the *Rating Scale* scores of 5.0 and 4.0 in Table 6.15 and by Figure 6.6b. Although he still wanted to do architecture, he doubted that he was going to receive the required tertiary entrance score. At the same time, he was missing the humanities. He had taken Geography and History in Year 10 but his concentration on mathematics and science in Year 11 meant that he could not also study a humanities subject. While he said he wouldn't mind doing an Arts degree majoring in medieval and ancient history, he felt that Arts degrees are fairly useless in general and really just a waste of time; just for personal interest because an Arts degree wouldn't get him a job. Alec said that memories of his Year 9 Investigation were perhaps still having a small negative effect on his motivation to continue to participate in science because he didn't enjoy doing it and he had to work during holidays.

Interestingly, despite achieving highly in the Australian Schools Science Competition in Year 11, Alec said that this competition had no effect on his motivation. While he enjoyed doing it because he was interested in how well he could go and he thought a good result looked good on a resume, he had come to regard it as "just a science competition, we do it every year, and I spasmodically go well, and spasmodically go badly." However, during the second half of Year 11 Alec became aware that he could study science at the tertiary level in areas other than the traditional biology, chemistry, and physics and this led to the increase in motivation to continue to participate in science shown in Figure 6.6b. This increase continued during Year 12 due to the fact that, although he still didn't know exactly what he wanted to do career wise, his research of possibilities at the University of Queensland led to him liking the freedom which a science degree could offer.

Alec indicated architecture as his fifth-choice on his tertiary admissions application, saying that although it motivated him for a while, he didn't think he would like to do it any more. He eventually enrolled in a Bachelor of Science/Applied Science course at the University of Queensland.

Scientists. Alec's Year 10 perception of a scientist was of a person who was intelligent, enquiring, eager, excited by anything new, usually unmarried and leading a solitary life, relatively old (with younger people studying with them), and of either sex. Alec said that, during his junior years, he regarded scientists as normal people (reinforced by the score of 9.4 on TOSRA Scale N in Table 6.16), with the Australian Schools Science Competitions having a positive effect on his perception of normality and exposure to practising scientists during the A.S.I.A. Summer School reinforcing this view of normality. In regard to the former he said: "They've stopped them [scientists] being the outlandish more way-out type of person and brought them down to a more down-to-earth type of person" and he said that, had he not done these activities, "I would have thought scientists to be very seclusive and, um, a little bit more haphazard and forgetful, not really like a real person." He also said that these competitions broadened his view of the type of experimentation in which scientists were engaged and also made him aware of their role in the analysis of data compared with experimentation alone.

During Years 11 and 12 his description of scientists moved further away from the stereotypical images associated with terms such as old, intelligent, and solitary which he used in Year 10. "I just . . . think of scientists as just science as just another occupation . . . like a mechanic or an architect or an engineer . . . and so it's sort of less stereotyped and they come in all ranges of people." He could not identify any reason for this change in view. During Year 12, Alec said that his increased awareness of the broad range of tertiary course offerings broadened his view of the type of work in which scientists were engaged.

Science in society. During interview near the end of Year 10, Alec said:

> the medical branch of science I feel is reasonably important, to develop new vaccines, new healing technologies, to try and cancel out some of the more major illnesses around. The sciences of physics, chemistry are reasonably important . . . more concerned with the long-term well-being of the

population or of a particular species . . . . Society does centre around sciences because any new achievements or developments are generally hard hitting and do affect the population . . . fairly decisively.

He said that, during his junior years, the A.S.I.A. Summer School, Queensland Museum Excursion, *Sciencentre* Excursion, and Investigation all broadened his perception of, and increased his view of the importance of, the role of science in society. The latter reinforced his perception "that scientists, sort of, or inventors contribute things to social life to aid people to make life easier etcetera." He also said that the Australian Schools Science Competitions reinforced his perception of the high contribution science makes to society.

Figure 6.6c and Table 6.17 confirm Alec's high opinion of the contribution of science to society during his senior years. During interview near the end of Year 11 he said that the Vacation Science Tour at the end of Year 10 reinforced this view and that exposure to newspaper articles and television programs during the year enhanced this view.

Towards the end of Year 12 he also said that he had formed the opinion, during his senior years, that important discoveries would, as opposed to having any immediate effect, not become public knowledge or have an impact on society for some years.

Summary. Table 6.18 summarises the data for Alec.

Andrew

Andrew came to the college as a boarding student in Year 8. He experienced five enrichment activities during Years 7 - 9, obtaining a Distinction in the Australian Schools Science Competition in Year 8. During his senior years he studied Biology and Chemistry, always with high levels of conduct and cooperation but with achievement and effort decreasing from ratings of B to C/D and 2/3 to 4, respectively. He was tardy in submitting tasks during this time, and staff perceived that he was underachieving. During Years 10 - 12, Andrew participated in four enrichment and six extracurricular activities and obtained another Distinction in the Australian Schools Science Competition in Year 10.

Interest and enjoyment. Andrew's interest and enjoyment in being involved in

Table 6.18
A Summary of the Data for Alec

Variable	Overall trend	Contribution		Longer-term effects
		Positive	Negative	
Interest and enjoyment	Decrease, then increase (no overall change)	Aust. Science Comp. (Yr. 7-10), Nat. Chem. Quiz (Yr. 10), A.S.I.A. School, *Sciencentre*, courses interesting, Chemistry Investigation	Investigation (Yr. 9), teacher, science achievement lower than desired, Physics Investigation	Aust. Science Comp. (Yr. 7), *Sciencentre*
Motivation	Increase	*Sciencentre*, Aust. Science Comps. (Yr. 7-10), Nat. Chem. Quiz (Yr. 10), A.S.I.A. School, future direction	Investigation (Yr. 9)	Investigation (Yr. 9)
Perceptions about scientists		Aust. Science Comp. (Junior), A.S.I.A. School, tertiary courses		
Role of science in society	No change	Aust. Science Comp. (Junior), A.S.I.A. School, Investigation, Museum, *Sciencentre*, newspapers/television, Vacation Tour (Yr. 10)		

science activities decreased, from a high level, during the study period (Figure 6.7a and Table 6.19). He said that his interest and enjoyment was influenced positively, to a small degree only, in Year 10 as a result of being a recipient of awards in both the Australian Schools Science Competition and the National Chemistry Quiz. His interest and enjoyment decreased during his senior years, as he found the study of biology and chemistry increasingly harder, the peak shown in Figure 6.7a reflecting nothing more than his perception of a "fresh start" to (senior) subjects.

Andrew found his Year 11 Work Experience involving leaf area sampling, soil

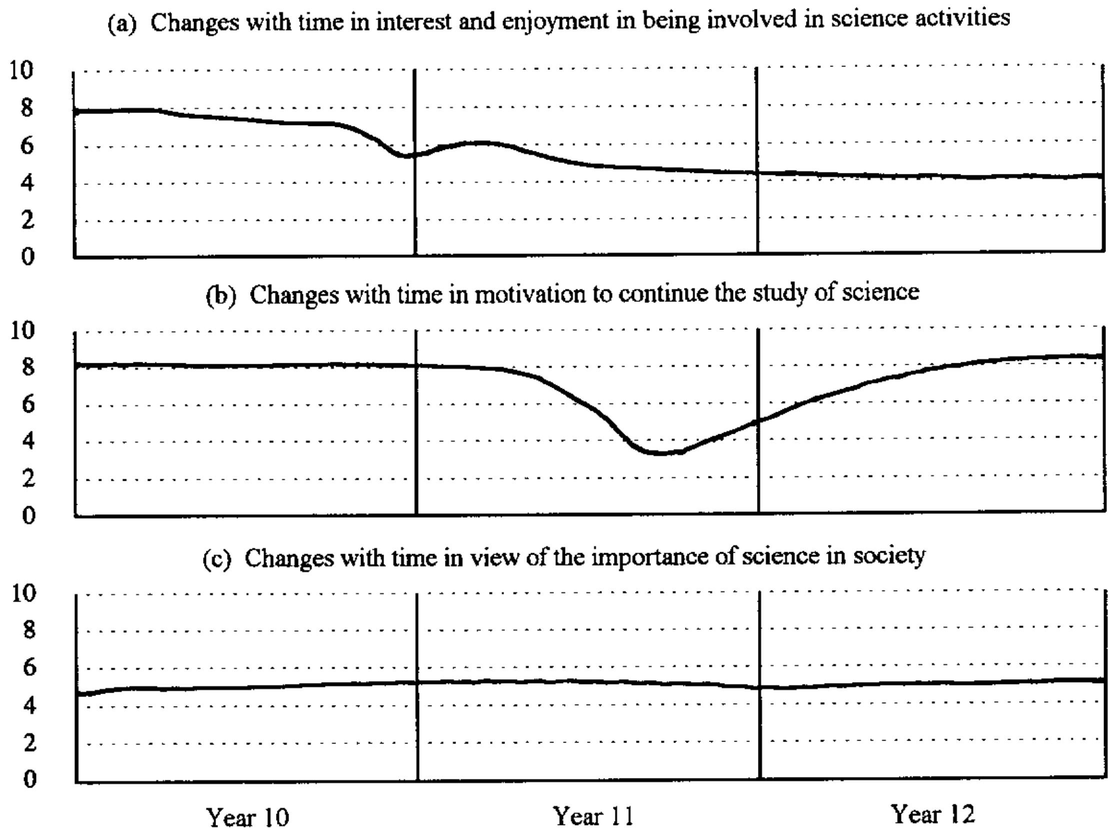

Figure 6.7. Graphs of retrospective trends: Andrew.

testing, and general tasks at a plant-breeding research station fairly boring and tedious, and while this experience decreased his interest and enjoyment in being involved in this type of science, he said it did not have this effect on being involved in science in a broader sense.

Motivation. During Year 10, Andrew planned to study biology and chemistry in his senior years with a view to enrolling in a veterinary science or agricultural science tertiary course. Some uncertainty regarding these career possibilities during Year 11 was followed by his interest in pursuing a rural technology course. He eventually enrolled in a Bachelor of Applied Science (Rural Management).

Andrew's motivation to continue to participate in science during the study period remained essentially constant and high (Figure 6.7b and the Rating Scale of Table 6.15), with the dip shown towards the end of Year 11 in Figure 6.7b due to Work Experience. However, this effect was short-lived as he said he was more interested in animals than plants and subsequently realised that he could continue to study science without necessarily working with plants in the manner in which he had during Work Experience.

Scientists. Andrew's Year 10 view of scientists was of people who carry out research, solve problems, and increase society's knowledge about phenomena. He felt that scientists could be either male or female and that, although he may have had visions of the "mad scientist" stereotype once, he no longer held that view (although he could not give any reasons for his change in view). This Year 10 perception of scientists persisted throughout his senior years.

His Year 9 Investigation involved a study of the effect of soil type on plant growth. This "just made me realise some of the things that they [scientists] had to do," and he mentioned the specific activities of graphing and making things. Although Work Experience showed him what scientists did at that location, he said that this activity had no real effect on his view of scientists.

Science in society. In Year 10, Andrew said that science had "a great deal to do with our lives, they come up with new technology and stuff . . . coming up with things to try and combat diseases and things like that" and this perception remained unchanged through to the end of Year 12.

His view of the importance of science in society remained essentially constant through Years 10 to 12 (Figure 6.7c). However, he said that Work Experience in Year 11 did increase, to a small extent, his view of the importance to the agricultural industry of research on the breeding of different strains of grain.

Summary. A summary of the data for Andrew is given in Table 6.19.

James

James came to the school as a day student in Year 11. He studied Senior Biology, Chemistry, and Physics with C-level achievement and ratings of 2/3 and 1 for effort and conduct and cooperation, respectively. James participated in eight enrichment and six extracurricular activities, being awarded a Distinction in the National Chemistry Quiz in Year 12.

Interest and enjoyment. James said that, during his junior years (at another school), a visit to the *Sciencentre* increased his short-term interest and enjoyment in doing those kind of activities (but not in doing science in general) and that a visit to an Artificial Insemination (A.I.) Centre, during which time topics on breeding and

Table 6.19
A Summary of the Data for Andrew

Variable	Overall trend	Contribution		Longer-term effects
		Positive	Negative	
Interest and enjoyment	Decrease	Aust. Science Comp. (Yr. 10), Nat. Chem. Quiz (Yr. 10)	Subjects difficult	
Motivation	No change		Work Experience	
Perceptions about scientists		Investigation		
Role of science in society	No change	Work Experience		

genetics were discussed, had a similar positive effect because he found it interesting and it was the type of work which he would like to do in the future.

He said that the R.A.C.I. Chemistry Lecture (because the carbon-dating technique interested him), Chemistry Investigation (in which he determined the heats of combustion of the first five alcohols, found the work not difficult, and obtained results which were satisfying because they demonstrated a trend), and coursework (which he found became more interesting as it became more complicated) all contributed to the increase in his interest and enjoyment in being involved in science activities to a very high level during his senior years (Figure 6.8a).

Motivation. James' motivation increased steadily, to a very high level, during the study period (Figure 6.8b). During Year 11, the National Chemistry Quiz (because he liked chemistry and the feeling that he could do the problems, as evidenced by his Credit award) increased his confidence and Work Experience (because it showed him that veterinary science is what he would like to do, and that he needs to improve his subject achievement to gain entry) increased his motivation to continue to participate in science. By the end of Year 11, although still having a desire to do veterinary science, he doubted that his tertiary entrance score would be sufficiently high to gain him entry and was looking towards a tertiary course involving "something to do with science."

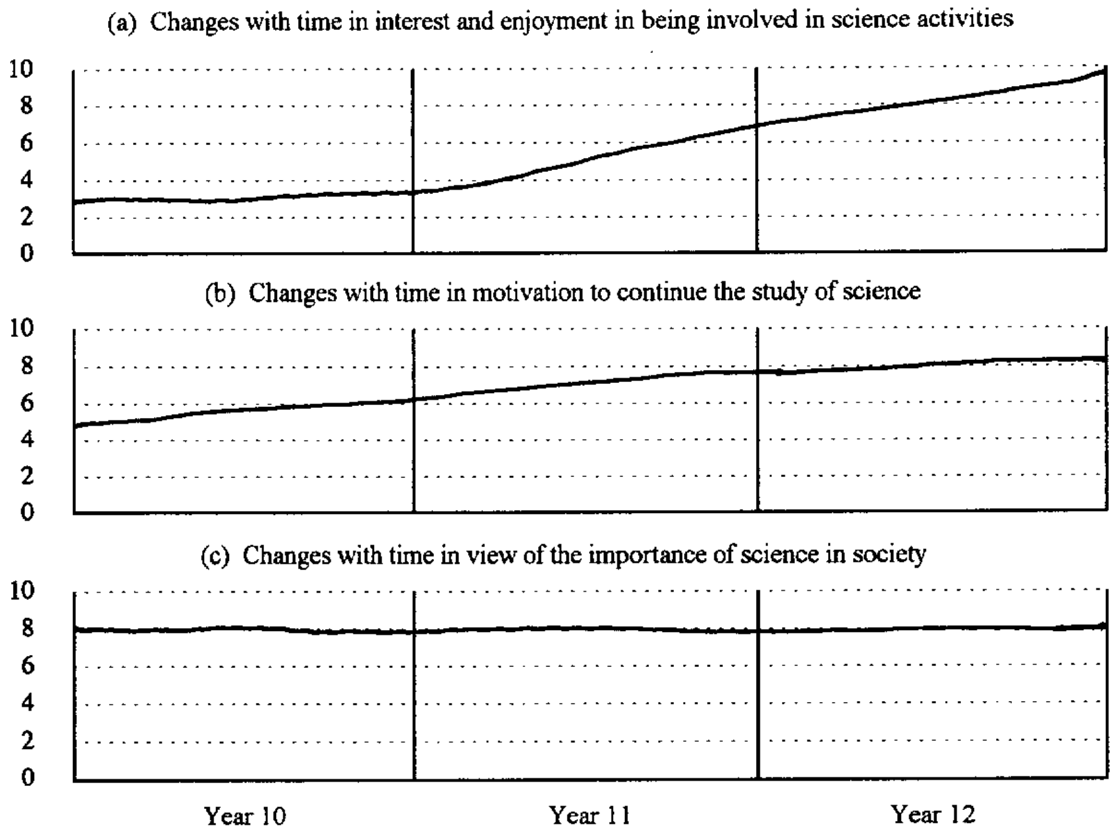

Figure 6.8. Graphs of retrospective trends: James.

Further increasing his motivation during Year 12 were the CSIROSEC visit (because he found the chemistry activities interesting and this motivated him to include more chemistry in a science degree), science coursework (because it increased his knowledge about what science involved and about the work of scientists), and his decision to pursue a tertiary science degree course. James subsequently enrolled in such a tertiary course, realising that he could still gain entry to veterinary science at a later time if he achieved highly enough.

Scientists. James' Year 11 view of a scientist as "just an ordinary bloke who's . . . a bit more intelligent than the average person" persisted throughout his senior years, with the R.A.C.I. Chemistry Lecture reinforcing his perception of the normality of scientists. Despite his use of the term *bloke* in the foregoing quotation, he assured the interviewer that either males or females could be scientists.

Science in society. James' view of the importance of science in society increased to a very high level through the study period (Figure 6.8c and Table 6.17). He said that, throughout his senior years, he regarded the role of science in society to be an important one, citing the contribution of medicine to a longer and an improved quality of life and everyday technologies used in cooking and transport as examples.

James said a visit to a power station and A.I. Centre (both when he attended a previous school), the R.A.C.I. Chemistry Lecture, Work Experience, and coursework all broadened his perception about the role of science in society, with Work Experience increasing his view of the importance of science in society as a result of observing the role veterinary surgeons play. As an example of the latter he mentioned the treatment of cows in need, stating that rural industries are the basis of our economy.

Summary. Table 6.20 summarises the data for James.

Table 6.20
A Summary of the Data for James

Variable	Overall trend	Contribution		Longer-term effects
		Positive	Negative	
Interest and enjoyment	Increase	R.A.C.I. Lecture, Chem. Investigation, coursework (*Sciencentre*, A.I. Centre)[a]		
Motivation	Increase	Nat. Chem. Quiz (Yr. 11), Work Experience, CSIROSEC Excursion, Chem. Investigation, coursework		
Perceptions about scientists		R.A.C.I. Lecture		
Role of science in society	Increase	R.A.C.I. Lecture, Work Experience, coursework (Power Station, A.I. Centre)		

[a]Activities in brackets are those in a previous school.

Luke

Luke entered the school as a day student in Year 8 and participated in five enrichment activities during Years 8 and 9, receiving a State prize for his Year 9 Investigation. In his senior years, he studied Biology, Chemistry, and Physics with mainly A-level achievement and very high effort and conduct and cooperation ratings. During Years 10 - 12, he engaged in eight enrichment and 12 extracurricular activities, obtaining a number of Distinctions in both the Australian Science Competition (a High Distinction in Year 11) and National Chemistry Quiz.

Interest and enjoyment. Luke said that the steady increase, to a high level, in his interest and enjoyment in being involved in science activities during Years 10 to 12 (Figure 6.9a and the Rating Scale data in Table 6.14) was due to progressively broader exposure to science content and exposure to interesting experiments. In addition, the Australian Schools Science Competitions during his junior years (because they were interesting and "sort of opened my eyes a little bit as to what other things there are, what um, sort of subjects science encompasses"), his Investigation involving the preparation of an insulation product made from sheep wool, aluminium foil, and cardboard (because it was fun and "I sort of realised that science work doesn't really have to be boring so um, interest in other sort of areas increased as well"), the *Sciencentre* (because he really enjoyed it and liked reading about the scientific principles involved), the A.S.I.A. Science Summer School (because it was fun, enjoyable, and broadened his awareness of different areas of science), the Primary Interface (because it was fun and he really enjoyed it), the Vacation Science Tours in Years 10 and 11 (because they gave behind-the-scenes insight into different types of work), and the R.A.C.I. Chemistry Lecture (because it was enjoyable and the concepts were not too difficult to understand and were explained well) all made positive contributions. The *Sciencentre* made the greatest short-term impact on his interest and enjoyment, and was also still having a longer-term effect in Year 11. In relation to his investigation, Luke also said that the out-of-class time required detracted somewhat from the overall appeal of the activity. "It was a bit of a hassle getting it done, sort of like, it was always on your conscience like in the holidays I thought ah, can't really do this because I've got to do my science project."

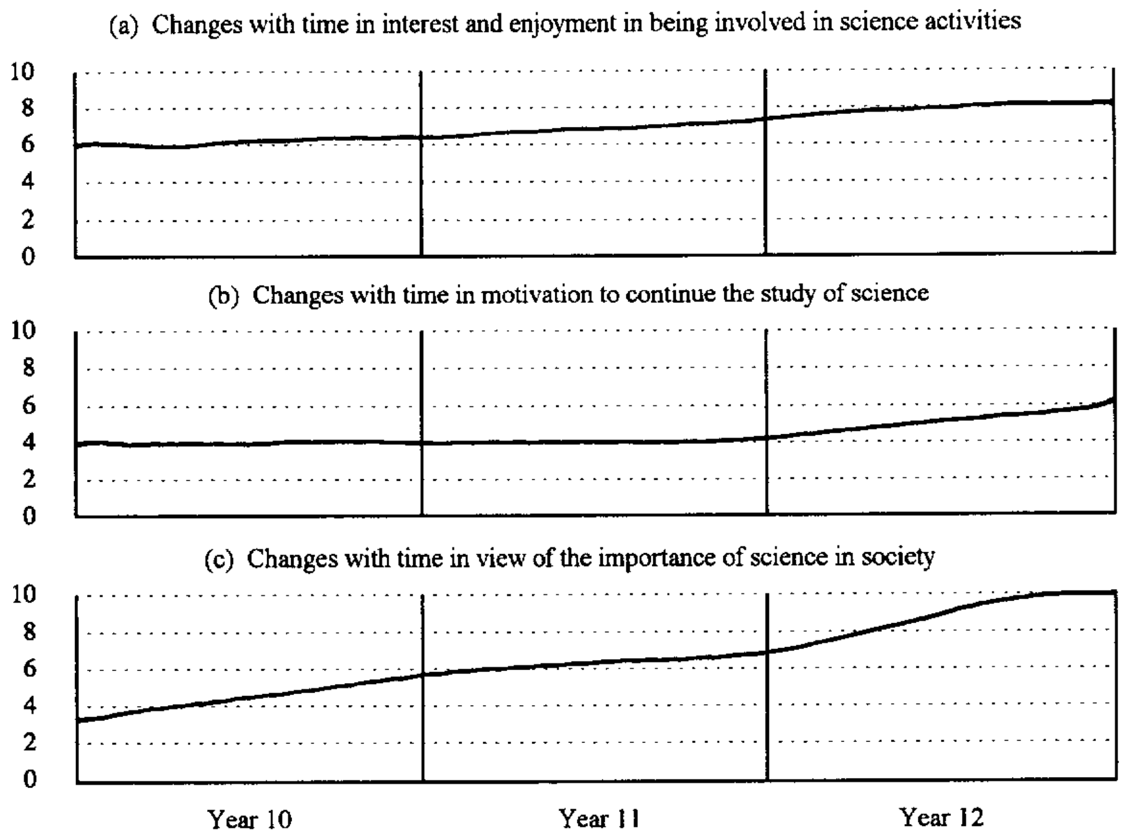

Figure 6.9. Graphs of retrospective trends: Luke.

Motivation. During his junior years, Luke said his motivation to continue to participate in science increased through his work on his Investigation (because "it sort of made me like science a bit more" and being awarded a prize at State level increased his confidence in his abilities to do science), the visit to the *Sciencentre* (because he found it enjoyable and it showed him that "it [science] doesn't have to be boring, it can be interesting"), and, most notably, his involvement in the A.S.I.A. Science Summer School (because he saw actual scientists and their work and it showed him that a science career could be very interesting and exciting). He also said that the Vacation Science Tour increased his awareness of some potential career possibilities while, at the same time, leading him to dismiss others.

Luke's motivation to continue to participate in science increased during the study period (Figure 6.9b and the Rating Scale data in Table 6.15). By the end of Year 10, Luke thought that he would probably embark on a science-based career (although he was unsure of any specifics) and decided to choose his senior subjects so as to keep his future options open.

During Year 11 Luke said that the Australian Schools Science Competition (because his High Distinction pointed to the fact that he may have an aptitude for science) and the R.A.C.I. Chemistry Lecture (because it showed him a few things like carbon dating that he would be interested in doing in the future) both increased his motivation. However, the Queensland Geology Competition (because he found the high difficulty level of the questions "off-putting") had the opposite effect on his motivation to pursue geology but not science in general. At the end of Year 11 he said that he was considering a tertiary course in engineering but that this was not definite.

During Year 12 Luke did Work Experience in the optometry field (perhaps as a result of one of the Vacation Science Tour visits to an optometry school, although this was not ascertained) and this, together with the practically guaranteed employment opportunity in the area, resulted in him adopting optometry as a career goal. As a result, as shown in Figure 6.9b, his motivation to continue to participate in science increased.

Scientists. When invited to describe, near the end of Year 10, his perception of a scientist, Luke gave a fairly stereotypical response, mentioning glasses, white coat, male gender, cleverness, absent-mindedness, and laboratory environment. Interestingly, however, he also said subsequently during the same interview that the A.S.I.A. Summer School (conducted the previous year) "changed it [his view of scientists] a lot because, um, the people who came in to lecture us were, um, really nice, friendly, um helpful and they were all really different people, not just the set image of glasses and all that kind of stuff . . . labcoat."

In any case, he subsequently said the Vacation Science Tour at the end of Year 10 led him to believe that scientists were "everyday characters," included females and outdoor work, and that the glasses and white laboratory coat image was restricted to certain types of work, such as chemistry, only. His general reading also contributed to this updated perception. Luke also said that the Australian Schools Science Competitions during his junior years, as well as the A.S.I.A. Science Summer School, broadened his perception of the type of work done by scientists, that the Investigation (during Year 9) "was sort of making, um, us be a scientist, sort of well made me realise that just about anyone could be a scientist if they really wanted to," and that the presenter of the R.A.C.I. Chemistry Lecture was "the classic scientist," reaffirming aspects of his earlier stereotypical image of scientists.

Science in society. Luke said that his view of the importance of science in society increased progressively during Years 10 to 12 (Figure 6.9c), citing closer attention to current affairs as a contributing factor.

He said during his Year 10 interview that the Australian Schools Science Competitions during his junior years, the National Chemistry Quiz, the A.S.I.A. Science Summer School, and his Investigation all broadened his view of the role of science in society and most, as a result, increased his view of the importance of science in society. In regard to the latter, he said:

> Um, well just doing something that doesn't seem very scientific [at the time] such as insulation, um, well basically made me realise that, you know you can basically apply science to just about anything so, um so, well just made me realise that science is pretty important in society.

At the time of this interview he identified the potential role of science in the processing and development, in Australia, of raw materials which were being exported, and he also perceived an increasing future role of sciences in areas such as the production of vaccines to fight diseases and the monitoring of greenhouse effects.

During later interviews he said that, in addition to classwork, the Vacation Science Tour (Year 10), R.A.C.I. Chemistry Lecture, and Biology Olympiads (because of some material pertaining to the carbon cycle) all had positive effects similar to the earlier activities identified above.

Summary. A summary of the data for Luke is given in Table 6.21.

Scott

Scott came to Glendale College as a day student in Year 8 and participated in five enrichment science activities during Years 8 and 9. During his senior years, he studied Chemistry and Physics with A/B-level achievement and very high ratings for effort and conduct and cooperation, as well as engaging in seven enrichment activities and volunteering for eight extracurricular activities. Through his secondary schooling, Scott achieved a number of Distinctions and High Distinctions in both the Australian

Table 6.21

A Summary of the Data for Luke

Variable	Overall trend	Contribution		Longer-term effects
		Positive	Negative	
Interest and enjoyment	Increase	Aust. Science Comps. (Junior), Investigation, *Sciencentre*, A.S.I.A. School, Primary Interface, Vacation Tour (Yr. 10, 11), R.A.C.I. Lecture, coursework		*Sciencentre*
Motivation	Increase	Investigation, *Sciencentre*, A.S.I.A. School, Aust. Science Comp. (Yr. 11), R.A.C.I. Lecture, Work Experience	Qld. Geology Comp.	
		Vacation Tour (Year 10)		
Perceptions about scientists		Aust. Science Comps. (Junior), Investigation, A.S.I.A. School, Vacation Tour (Yr. 10), R.A.C.I. Lecture, general reading		
Role of science in society	Increase	Aust. Science Comps. (Junior), Nat. Chem. Quiz (Yr. 10), Investigation, A.S.I.A. School, Vacation Tour (Yr. 10), R.A.C.I. Lecture, Biol. Olympiads, classwork, media		

Schools Science Competition and the National Chemistry Quiz.

Interest and enjoyment. Scott said that the *Sciencentre* visit (because the hands-on aspect was good fun), Primary Interface (because it was enjoyable and fun), R.A.C.I. Chemistry Lecture (because it was really interesting), and A.S.I.A. Science Summer School (because it was really enjoyable and "it's just shown me how much fun science can be") all increased his interest and enjoyment in being involved in science activities, with the latter having the more pronounced effect. He also said that the slight increase in interest and enjoyment, to the final high level shown in Figure 6.10a, during Year 12 was the result of his changing his proposed career path to the science-based physiotherapy.

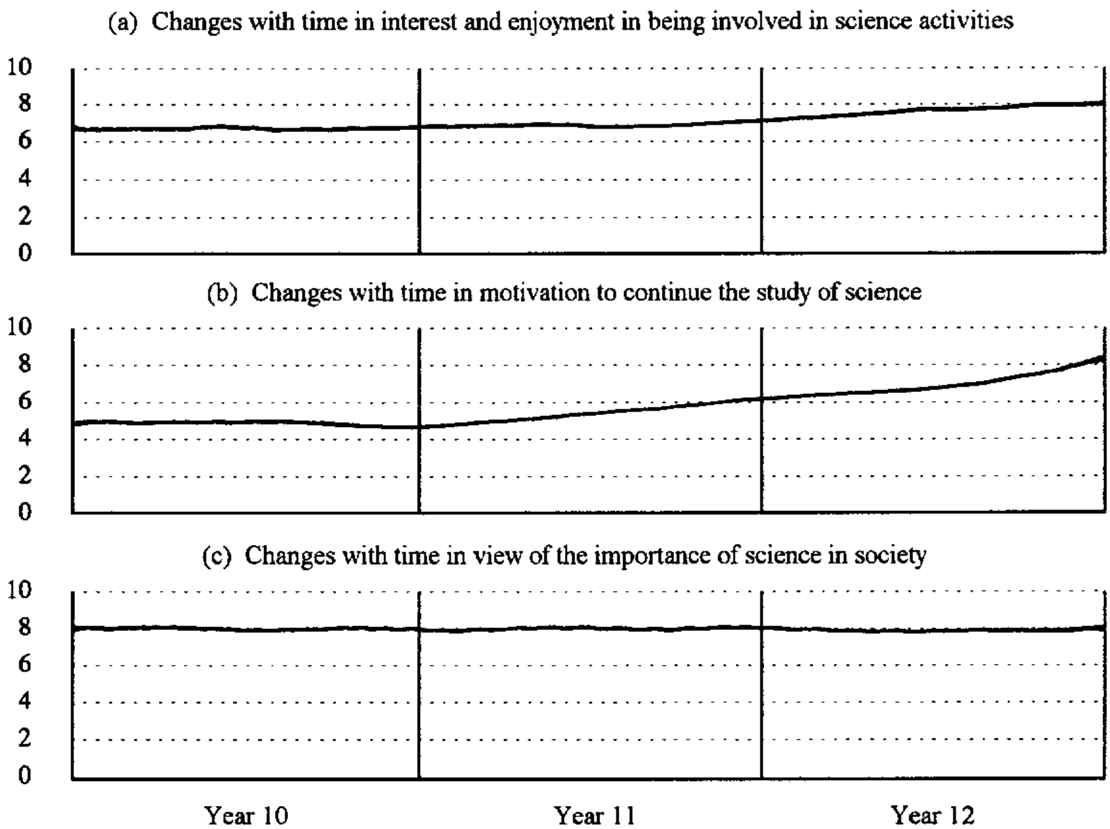

Figure 6.10. Graphs of retrospective trends: Scott.

Motivation. Scott said that during his junior years, the Australian Schools Science Competitions (because he was awarded Distinctions in some), the National Chemistry Quiz (because he was awarded a High Distinction), the *Sciencentre* Excursion (because it invited him to try to find things out for himself), and the A.S.I.A. Science Summer School (because it was interesting) all contributed to increasing his motivation to continue to participate in science. During his Year 10 interview he said that he was unsure of his future course and career direction, although he thought the maths/computing area was a quite probable option.

During Year 11 he said he was still uncertain about his future direction, thinking about the possibilities offered in the computing/business areas and also the science-based courses in which he was interested. The A.S.I.A. Science Summer School was still having an effect on him during Year 11, reminding him of a broad range of possible science-based careers, and forensic science in particular. However, as shown in Figure 6.10b, his motivation increased markedly to a high level in Year 12 as a result of Work Experience, following which he decided to aim for tertiary studies in physiotherapy (or science studies followed by a transfer to physiotherapy).

Scientists. During his Year 10 interview Scott described scientists as persons who were fairly smart, inquisitive, liked to achieve goals, and enjoyed the success of achieving a goal, adding that "basically anyone could be a scientist." This perception remained with him during his senior years. He said that the A.S.I.A. Science Summer School, R.A.C.I. Chemistry Lecture, and visit to the CSIROSEC all reinforced his view of the normality of scientists, with the first activity also demonstrating to him that the work of scientists can be more interesting than it sometimes appeared to be.

Science in society. During his Year 10 interview Scott said that science "helps us to find quicker, more efficient, um, safer methods of doing jobs and also helps, um, provide ways of transport like a car or something and things like that," that science can contribute significantly to curing diseases, and that science investigates our surroundings, how things affect us, and how we affect the environment. He said his Investigation involving the recycling of paper and cardboard showed him that science techniques can "help to improve the way we do things."

This high perception of the role of science in society, together with his view of the importance of science in society (Figure 6.10c), did not change during his senior years.

Summary. Table 6.22 summarises the data for Scott.

Table 6.22
A Summary of the Data for Scott

Variable	Overall trend	Contribution		Longer-term effects
		Positive	Negative	
Interest and enjoyment	Increase	*Sciencentre*, A.S.I.A. School, Primary Interface, R.A.C.I. Lecture, adoption of career goal		
Motivation	Increase	Aust. Science Comps. (Junior), Nat. Chem. Quiz (Yr. 10), *Sciencentre*, A.S.I.A. School, Work Experience, career focus		A.S.I.A. School
Perceptions about scientists		A.S.I.A. School, R.A.C.I. Lecture, CSIROSEC		
Role of science in society	No change	Investigation		

In the next chapter, the data for these 10 senior students is analysed across students in two different ways. First, each dependent variable is considered in turn and results about how and why they changed are developed. Then, the effects of individual science activities on these variables are considered.

CHAPTER 7

Results and Analysis: Senior Sample, Phases 2 and 3

This chapter reports the second and third phases of data analysis for the senior sample students. In Phase 2, the first and second research questions (i.e. how and why do students' interest and enjoyment in being involved in science activities, their motivation to continue to participate in science, and their perceptions about scientists and the role of science in society change during the period of the study) are addressed. Each dependent variable is once again considered in turn and data from the 10 senior sample students used to develop a set of generalisations about changes in each dependent variable. In Phase 3, a further set of results about the effects of individual enrichment and extracurricular science activities on the dependent variables (the third research question), grouped in the overlapping categories of competitions, excursions, and practical work, is developed.

As in chapter 5 for the junior sample, the general structure adopted is to draw the evidence into a generalisation and then discuss it. The discussion typically provides evidence to support the generalisation and an acknowledgment, if possible, of counter evidence. In all sections of this chapter, data come from Years 10 to 12 activities in which students participated at Glendale College only, plus pre-Year 10 activities for which the data supplement either the chapter 5 conclusions for junior sample students or Years 10 to 12 data for the senior students.

7.1 Interest, Enjoyment, and Motivation

How These Variables Changed

The overall trend (i.e. increase, no change, or decrease) in the motivation of senior sample students to continue to participate in science also correlates strongly with the trend in their interest and enjoyment in being involved in science activities, and both these variables increased, for the group as a whole, during the study period. In all but three cases, the trend in a student's interest and enjoyment is identical to the trend in their motivation; in the three exceptions, an increase or decrease in one of these dependent variables is matched with no change in the other. The interest and enjoyment of 6 (3 girls and 3 boys) of the 10 students increased, that of two students (one girl and one boy) did not change, and the interest and enjoyment of Ruth and Andrew decreased. The motivation of seven students (three girls and four boys) increased, that of Andrew did not change, and the motivation of Angel and Ruth decreased. Six of the seven students whose motivation increased enrolled in science-based tertiary courses; the only other student to do so was Andrew.

It is difficult to identify any relationship between trends in either students' interest and enjoyment or their motivation and their achievement in science. Of the six students whose interest and enjoyment increased, three had A or A/B achievement levels and the other three had B/C, C, and C/D; an increase in a student's interest and enjoyment in being involved in science activities can apparently occur at any of a number of achievement levels. The two students whose interest and enjoyment did not change had B levels of achievement, although the interest and enjoyment of both Ruth and Andrew did decrease, as a result of finding coursework difficult, as their achievement dropped from a B to C/D level. About all that can be said about students' motivation is that there was no increase in the motivation of the two students whose achievement decreased during the study period.

Why These Variables Changed

As with the junior sample, participation in enrichment and extracurricular science activities made a frequent contribution to increases in both students' interest and enjoyment in being involved in science activities and their motivation to continue to participate in science. In all, these activities made 30 positive contributions to students' interest and enjoyment in 138 possible opportunities (i.e. possible student - activity combinations), involving 12 of the possible 24 activities and every student, with the only negative contribution coming from Alec, who found his Physics Investigation frustrating.

At least one activity made a positive contribution to the motivation of 9 of the 10 senior students. In all there were 32 positive and 5 negative contributions to students' motivation, in the total of 138 possible opportunities and involving 15 of the total 24 activities. In 17 of these occurrences, the activity also had a corresponding positive effect on students' interest and enjoyment. Details of the effects of individual activities are addressed in Phase 3 of data analysis reported later in this chapter.

Coursework considerations also impacted significantly, and mainly positively, on students' interest and enjoyment, with 8 of the 10 students being positively affected by classwork being interesting (4 students), more detailed compared with science at the junior level (4 students), or applicable to everyday life (1 student). Two students found that the difficulty of coursework reduced their interest and enjoyment. While adoption of a career goal impacted positively on the interest and enjoyment of one student, other negative effects included being annoyed at their teacher, achieving at a lower level than desired, and demands such as practical reports.

The reasons for changes in students' motivation (including the effects of science activities) can again be considered as affective or utilitarian in nature. Four girls and all five boys were influenced by affective considerations which were largely positive and included interest, enjoyment, fun, caring people, and new learning. The couple of negative influences, given by one student each, were lack of enjoyment and the boring and tedious nature of Work Experience. Utilitarian influences affected all five girls and all of the boys except Andrew. Of these, career considerations made a positive impact on four girls and the four boys, as a result of adoption of a science-based career goal, a broadening in students' perception of the range of science activities and associated future career opportunities, and/or the desire to keep career options open. Other positive utilitarian influences were concerned with success (most often evidenced by the receipt of an award, and experienced by three girls and the four boys), with difficulty in understanding coursework or answering quiz questions (influencing four girls and one boy) the only negative contributions.

7.2 Perceptions About Scientists

How This Variable Changed

Nine of the 10 students described scientists in normal terms, in nearly every case from the beginning of Year 10. The only exception was Alec who had some negative Year 10 stereotypical images which were negated by Year 11. Five students mentioned holding some negative stereotypical perceptions during their junior years, but in all cases except Alec, these had been negated by Year 10. Abi appeared to hold two conflicting perceptions (normal and a negative stereotype) simultaneously. Eight students held positive stereotypical images during the entire study period.

Why This Variable Changed

Participation by students in enrichment and extracurricular science activities had some effects (18 instances in 138 opportunities, involving 6 of the 10 students and 11 of 24 activities) on changes in their perceptions about scientists, and a synthesis of the nature of these effects appears later in this chapter. Other influences were coursework, the breadth of tertiary science courses offered, and general reading.

7.3 Role of Science in Society

How This Variable Changed

During their first interview (which occurred for six students towards the end of Year 10 and for the other four towards the end of Year 11), senior students were unanimous in acknowledging the important role of science in society. The following exemplify the contributions they identified: science permeates life, is a key in future problem-solving, helps prevent skin cancer, has taken over from superstitions and religions, helps us to find out more about the world and detrimental influences (greenhouse, CFCs, ozone), is improving the world, prevents and cures diseases, provides the basis for new technologies (cooking, transport), is contributing to longer and better quality lives, is producing more efficient and safer ways of working; "everything is science." Even Ruth, in expressing regret that science contributes to developing new and faster ways to kill people, sees this contribution as a reality of life.

The views of 6 (all 5 girls but only 1 boy) of the 10 students about the importance of science in society increased during the study period. (Sample girls and boys were similarly represented in the three senior science courses; Biology, Chemistry, and Physics.) In no case did a student's view decrease.

Why This Variable Changed

Students' participation in enrichment and extracurricular science activities had a positive effect on them in 19 instances out of 138 opportunities (i.e. possible student-activity combinations) involving 10 of the 24 activities and 6 (3 girls and 3 boys) of the 10 students. Here, as for the junior sample, a positive effect is considered to be one which broadened a student's perception of the role of science in society and/or increased their view of the importance of science in society. Details of the effects of these activities are reported later in this chapter.

However, six students referred to coursework and five to current affairs media (newspapers, television) as positive influences on their perceptions about the role of science in society. The only other positive contribution originated from Alec's research of tertiary course prerequisites, and there were no negative contributions.

The final sections of this chapter report Phase 3 of the data analysis, in which the effects of individual enrichment and extracurricular science activities (grouped as competitions, excursions, practical work, and guest evenings) are considered.

7.4 Competitions

Competitions were all external in nature and comprise the Australian Schools Science Competition (Years 8 - 12), National Chemistry Quiz (Years 10 - 12), Queensland School Geology Competition (Year 11), and Biology Olympiads (Year 11).

Interest, Enjoyment, and Motivation

Both the Australian Schools Science Competition and the National Chemistry Quiz impacted broadly by increasing the short-term interest and enjoyment of senior sample students in being involved in science activities and/or their motivation to continue to participate in science. These competitions positively influenced, at some time, 6 (2 girls and 4 boys) and 8 (4 girls and 4 boys) of the 10 sample students, respectively. As for the junior sample, the most frequent reason for this positive influence was the receipt of an award, given by four of the six students in the case of the Australian Schools Science Competition (seven students received awards at some time) and six of the eight students for the National Chemistry Quiz (in which seven students received awards at some time). Alec's Year 7 award had a longer-term effect on his interest and enjoyment.

Other reasons for the positive effect of the Australian Schools Science Competition were that it was interesting, broadened a student's perception of the breadth of topics which constitute science, and created a desire to learn what was considered novel material. For the National Chemistry Quiz, students said it was interesting, it was enjoyable, they learned about the properties and reactions of different chemicals, they learned the meaning of new terms, and it broadened a student's view of the role of science in society. No student reported any negative effects of either competition on their interest and enjoyment or their motivation.

Of the six students (two girls and four boys) who sat for both the Australian Schools Science Competition and the National Chemistry Quiz during their junior years, only Luke said that sitting for the same competitions during Years 11 and 12 had a significant effect, despite these students being awarded, between them, five Distinctions and one Credit in the Australian Schools Science Competition and three High Distinctions, four Distinctions, and two Credits in the National Chemistry Quiz during their senior years. Luke said that the High Distinction he received in the Australian Schools Science Competition in Year 11 (he was awarded a Distinction in each of Years 8, 9, and 10) increased his motivation. Rachel said that both her Year 10 and 11 High Distinctions in the National Chemistry Quiz increased her motivation and resulted in her considering tertiary chemistry as an option.

Of the other four students in the cohort (all of whom entered the college at the beginning of Year 11), Wendy reported a first-time-only effect of the Year 11 Australian Schools Science Competition on her motivation (even though she wasn't an award winner) and Angel, Wendy, and James experienced first-time-only positive effects on their interest and enjoyment and/or their motivation in conjunction with the National Chemistry Quiz (for two of them, as a result of receiving an award). Apart from Luke, the only other students in the senior sample to receive a higher award on a subsequent sitting of either competition were Abi and James; they each received their only Credit in the Australian Schools Science Competition in Year 12, with James' Distinction in the Year 12 National Chemistry Quiz improving on the Credit he received in Year 11. In neither case, however, did the higher subsequent award affect the student's interest and enjoyment or motivation.

While neither the Queensland School Geology Competition nor the Biology Olympiads had any positive effects on the interest and enjoyment or motivation of the nine students and two students, respectively, who participated, the difficulty of the questions on the former influenced three of the nine students not to pursue geology in the future, including one of the four students who was awarded a Credit. Analysis of the paper (see appendix 7.A) showed that students lacked required prerequisite content knowledge to answer the majority of questions on the paper. It is also noted that in the time between students sitting for this competition and the writing of this report 4 years later, the competition has not again been offered. In contrast, Ruth (who did not receive an award) said the geology competition increased her motivation because it made her aware that geology was another post-secondary option.

Scientists

Ruth and Luke said that participation in the Australian Schools Science Competition during their junior years broadened their perception of the type of work which science can involve, and Alec found such participation to increase his view of the normality of scientists. In no case was there any effect during subsequent years. The National Chemistry Quiz, Queensland School Geology Competition, and Biology Olympiads had no effects on students' perceptions about scientists.

Science in Society

The first sitting only of the Australian Schools Science Competition increased Alec's, Wendy's, and Luke's view of the importance of science in society by broadening their perception of the role of science in society (e.g. smoking and other life issues and mining) and reinforced Alec's view of this importance. The National Chemistry Quiz had the same positive broadening effects on Alec, again in conjunction with his first sitting only, as did the carbon cycle material in the Biology Olympiad on Luke. The Queensland School Geology Competition had no effects in this area.

7.5 Excursions

Excursions required students to travel to off-college-campus venues, and comprise Vacation Science Tours (Years 8 - 11), A.S.I.A. Science Summer School (Year 10), R.A.C.I. Schools Lecture (Year 11), and CSIROSEC Excursion and Youth Physics Lecture (Year 12).

Interest, Enjoyment, and Motivation

The Vacation Science Tours during Years 9, 10, and 11, the A.S.I.A. Science Summer School, and the R.A.C.I. Schools Lecture all increased the short-term interest and enjoyment in being involved in science activities and/or the motivation to continue to participate in science of most participants. The Vacation Science Tours had this positive effect on three (two girls and one boy) of the five students who volunteered to be involved, mainly because they broadened students' perceptions about future opportunities in the sciences and because they were interesting. In addition, Ruth "saw what forensic science involved" and this had a longer-term positive effect on her interest, enjoyment, and motivation.

The A.S.I.A. Science Summer School increased both the interest and enjoyment and the motivation of all four students (one girl and three boys) who chose to participate, mainly because it was interesting, fun, and enjoyable. Other reasons given were, for increasing interest and enjoyment, being educational, showing new things, letting a student discover for himself/herself, and broadening awareness of the different areas of science and, for motivation, caring personnel. The broadening effect of the school on Scott's view of the breadth of possible science-based careers had a longer-term effect on his motivation to continue to participate in science.

The R.A.C.I. Schools Lecture positively influenced the interest and enjoyment and/or motivation of five (two girls and three boys) of the seven (three girls and four boys) students who attended, mainly because they found it interesting. Other reasons given for this effect on interest and enjoyment were fun, enjoyable, and concepts not too difficult and well explained and, on motivation, revealing a possible tertiary avenue. Because she found it fun and interesting, the lecture had a longer-term effect on both Abi's interest and enjoyment and her motivation.

Of the seven students (three girls and four boys) who participated in the CSIROSEC Excursion, only James reported a positive effect; on his motivation only, because he found it interesting. The Youth Physics Lecture had no effects on students' interest and enjoyment or their motivation.

Pre-Year 10 activity. The *Sciencentre* visit during Year 9 increased the short-term interest and enjoyment and/or the motivation of five (two girls and three boys) of the six (two girls and four boys) students who participated (both interest and enjoyment and motivation in the case of four students), predominantly because it was interesting, fun or enjoyable, and hands-on. Other reasons given for the effect were, in the case of interest and enjoyment, varied activities and results could be seen and heard and, for motivation, the variety in the activities broadened one student's view of the scope of scientific endeavour.

Scientists

The most common effects of excursions on senior students' perceptions about scientists were that they negated the stereotypical image of a scientist or reinforced the normality of scientists. This result applied to the Vacation Science Tours (for two of the five students who participated), the A.S.I.A. School (for all four students), the R.A.C.I. Schools' Lecture (two of seven students), and the CSIROSEC Excursion (one of seven students). In contrast, Luke said that the R.A.C.I. Lecture reinforced his earlier stereotypical image of a scientist because the presenter was "the classic scientist." In addition, one student each said that the Vacation Science Tours broadened their view about the type of work in which scientists engage and that the A.S.I.A. School demonstrated that the work of scientists can be more interesting than it sometimes appeared to be. Neither the Youth Physics Lecture nor the *Sciencentre* Excursion (a pre-Year 10 activity) had any effects on students' perceptions about scientists.

Science in Society

The most common effects of excursions on students' perceptions about the role of science in society were that they broadened or reinforced students' views or highlighted a social application of science, nearly always also increasing sudents' views of the importance of science in society. This effect was experienced by participants in the Vacation Science Tours (four of the five students), A.S.I.A. Science Summer School (three of four students), R.A.C.I. Schools' Lecture (three of seven students), and the *Sciencentre* Excursion (a pre-Year 10 activity, by two of six students). Neither the CSIROSEC Excursion nor the Youth Physics Lecture affected students' perceptions about scientists.

7.6 Practical Work

These activities, requiring students to engage predominantly in practical work, comprise the Primary Interface (Year 10), Evening Science (Year 11), Work Experience (Years 11 and/or 12), and Science Club and the Biology, Chemistry, and Physics Investigations (Year 12).

Interest, Enjoyment, and Motivation

Four of the seven practical work activities had positive effects on the interest and enjoyment and the motivation of many senior students, while three activities had a negative effect on one student only each. Science Club had no effects on the six students (three girls and three boys) who attended.

The Primary Interface increased the interest and enjoyment of three (one girl and two boys) of the five students (two girls and three boys) who volunteered, mainly because they found it enjoyable and fun and, in one case, because the student observed the primary student visitors enjoying it. Participation also increased Ruth's motivation because it broadened her perception about what science could involve.

Work Experience had a positive effect on the interest and enjoyment of two girls of the seven (three girl and four boy) participants because Ruth found forensic science enjoyable and the personnel helpful if she showed an interest, and Wendy was attracted by the variety and technology involved in radiography. Most significant, though, is that Work Experience increased the motivation of six (three girls and three boys) of the seven students to continue to participate in science because it reinforced a desire to study in a particular area, was interesting, or opened a possible tertiary option. In contrast, Andrew found his work with plants boring and tedious, decreasing his motivation to continue with this type of science but not science in a broader sense. Work Experience had longer-term effects on Ruth's motivation and both Wendy's interest and enjoyment and her motivation.

The Biology Investigation influenced only one of the seven students who completed it; Abi experienced an increase in her interest and enjoyment only because she enjoyed her chosen work in which she was interested and about which she was curious. The Chemistry Investigation positively influenced the interest and enjoyment of 4 (2 girls and 2 boys) of all 10 students who completed one, plus the motivation of two of these students as well. This effect on interest and enjoyment was a result of the Chemistry Investigation being found interesting and a challenge and allowing students to use their own experimental design, as well as students enjoying practical work more than theory and obtaining satisfactory results. The reasons for the positive effect on motivation were that the activity allowed Ruth to experience success with a forensics test she had seen during Work Experience and because the activity was interesting. Of the seven students (three girls and four boys) who completed a Physics Investigation, Alec reported a negative effect on his interest and enjoyment because he found his work annoying, boring, and repetitive, other students tampered with his apparatus, and he regarded his results as "lousy."

Ruth was the only student to attend Evening Science, on one occasion only. She said the experience decreased her motivation a little because even when she got help with physics problems she couldn't do them and this made her feel "degraded, stupid, dumb."

Pre-Year 10 activities. The Year 9 Investigation increased both the interest and enjoyment and the motivation of three (two girls and one boy) of the six students (two girls and four boys) who completed it, often because it was found to be interesting and enjoyable and showed that science can be interesting. Other reasons for this effect were that it showed how something scientific could be achieved at home, showed that other people (mentors) enjoyed their work, and Luke's State prize increased his confidence in his ability to do science. In contrast, Alec said this activity decreased his interest and enjoyment a little (because he found it difficult to think of something to do, a big task, intimidating, and he made mistakes) and also decreased his motivation a little and in the longer term (because he didn't enjoy doing it and he had to work during holidays). Alec was also the only senior sample student to participate in Science Club during Years 8 and/or 9, and he claimed no associated effect on his interest and enjoyment or his motivation.

Scientists

Five practical work activities had no effects on senior sample students' perceptions about scientists; Evening Science and Science Club, both of which had only one student participate, and the Biology, Chemistry, and Physics Investigations.

The Primary Interface, because most of the prepared demonstrations were chemistry-based, led Ruth to conclude that scientists deal with many different chemicals and Work Experience negated the stereotypical image (or reinforced normality) of scientists in the case of two girls of the seven students who participated. These girls also said Work Experience demonstrated that the research-oriented lifestyle of a scientist was interesting and that scientists had many different attitudes to life and work, respectively.

Pre-Year 10 activities. Only the Year 9 Investigation had any effect. It caused Andrew to realise some of the skills (e.g. graphing, construction) a scientist had to use and, by asking Luke to act like a scientist, led him to think anyone could be a scientist if they wanted.

Science in Society

Work Experience was the only practical work activity to influence students' perceptions about the role of science in society, increasing the view of the importance of science in society of four (two girls and two boys) of the seven students who participated by broadening their perception of the contribution science makes (how forensic evidence such as hair and fingerprints are used, new technologies which are improving medical standards, the importance of grain breeding research for the agriculture industry, and the work of a veterinary surgeon).

Pre-Year 10 activities. The Year 9 Investigation had a positive effect on four (one girl and three boys) of the six students (two girls and four boys) who completed it, mainly as a result of it broadening their view of the contribution of science to society. Other reasons given were that it showed how science can help to improve the ways we do things and that it demonstrated community concern about the dangers associated with mining to be unfounded.

7.7 Guest Evenings

Only two senior sample students attended an Evening Science with a Guest activity. The Tom Kirkpatrick evening changed Ruth's negative stereotypical image by increasing her view of the normality of scientists. The Sid Miller Evening increased both Rachel's interest and enjoyment in being involved in science activities (because she had been interested in veterinary science and the diversity and interesting nature of the fields of this discipline attracted her) and her motivation to continue to participate in science (because it reinforced her desire to study veterinary science).

For ready reference, the effects on students (including junior sample students) of competitions, excursions, and practical work activities are summarised in tabular form in Appendices 8.A, 8.B, and 8.C, respectively. In chapter 8, the final chapter, this study is summarised and a set of conclusions and implications are developed.

CHAPTER 8

Summary, Conclusions, and Implications

This chapter begins with an overview of the study. Then, the findings of the study are summarised; first by addressing changes in students' interest and enjoyment in being involved in science activities, their motivation to continue to participate in science, and their perceptions about scientists and about the role of science in society (the first two research questions) and then by considering the effects of participation in science activities on these dependent variables (the third research question). Finally, the conclusions and implications of the study are presented.

8.1 An Overview of the Study

The aim of this research was to study the influences of a program of enrichment and extracurricular science activities on students' affect, defined as the students' interest and enjoyment in being involved in science activities, their motivation to continue to participate in science, and their perceptions about scientists and about the role of science in society. In particular, the research focussed on:

1. how each of these affective variables changed during 2.5 years of secondary education,

2. why they changed, and

3. what effects student participation in the enrichment and extracurricular activities had on the variables.

A quasi-longitudinal case study research design involving both qualitative and quantitative methods of data collection was used. A group of Year 8 students was followed from the beginning of their Semester 2 through to the end of Year 10, while a group of senior students was simultaneously followed from the beginning of their Semester 2, Year 10 till the end of Year 12. Allowing for the demands of attrition, more detailed data were collected from a subsample of students from each of these cohorts; 10 students (5 girls and 5 boys) from each group.

Data collection involved structured interviews, surveys (including attitude scales), written records, and observations. Data were analysed in three successive phases. Phase 1 involved summarising in case study format, for each of the final 20 sample students, how and why their interest and enjoyment in being involved in science activities, their motivation to continue to participate in science, and their perceptions about scientists and about the role of science in society changed during the study period and what effects participation in enrichment and extracurricular activities had on these variables. In Phase 2, each of these dependent variables was considered in turn. Data from all 20 sample students were used in a search for changes in each variable, including how and why they changed. During Phase 3 of the analysis of data, each enrichment and extracurricular science activity was considered in turn in terms of its effect on each dependent variable.

8.2 Summary of Findings for the Dependent Variables

Interest, Enjoyment, and Motivation

How these variables changed. It is clear that trends in the interest and enjoyment of both junior and senior sample students in being involved in science activities are similar to trends in their motivation to continue to participate in science. This finding is in accord with the literature reviewed in section 2.3.

The interest and enjoyment of both the junior and senior sample students increased during the study period, with the increase slight for the junior sample but more pronounced for the senior group. While overall, the motivation of the junior sample did not change, that of the senior sample increased. Seven of the 10 senior sample students eventually enrolled in science-based tertiary courses.

It is difficult to identify any trend in the interest and enjoyment or motivation, of either junior or senior sample students, and their science achievement, although the only two senior students whose achievement declined during the study period also experienced a decrease in one or both of their interest and enjoyment or motivation. This finding supplements the consensus of the literature, reported in section 2.2, that there is little relationship between the interest and enjoyment of students and their achievement in science.

Why these variables changed. Participation in enrichment and extracurricular science activities made a consistently positive impact on increasing both junior and senior students' interest and enjoyment in being involved in science activities and their motivation to continue to participate in science. Coursework also impacted frequently on trends in both junior and senior students' interest and enjoyment in being involved in science activities; both positively and negatively for junior students but mainly positively for the senior sample. Positive reasons were a general liking for, and/or an understanding of, coursework topics, but also included the more detailed nature of senior science subjects compared with junior science. Negative reasons reflected a dislike for coursework topics and a lack of understanding of the concepts involved.

Reasons for changes in the motivation of both junior and senior students to continue to participate in science were classified as affective or utilitarian. Affective reasons, particularly those involving a liking, mainly positively affected the motivation of most junior and senior boys and girls; in fact, slightly more boys than girls. Utilitarian reasons affected the motivation of students in both positive and negative ways; positively mainly as a result of career-oriented considerations and/or students experiencing success by obtaining awards in competitions, and negatively by the difficulty students experienced in understanding concepts or achieving to their satisfaction (experienced mainly by junior and senior girls).

Adoption of a future career direction increased the motivation of most senior students and junior boys but only one junior girl. Also, the broadening of students' perceptions of career opportunities in science-based vocations increased the motivation of many senior students and all junior boys, but no junior girls.

Perceptions About Scientists

How this variable changed. Throughout the study period, both junior and senior sample students generally held perceptions that scientists were normal people, although five senior students said that they did hold some negative stereotypical views during their junior years, but also that these had been negated by Year 10. Further, 13 of the 20 sample students held positive perceptions about scientists at some time during, if not for the entire, study period.

Why this variable changed. Participation by students in enrichment and extracurricular science activities made a positive impact on both junior and senior students' perceptions about scientists, although far more frequently for junior students. Other influences on students' perceptions about scientists were coursework, book reading, television, and acquired knowledge about the breadth of science courses offered by tertiary institutions.

Role of Science in Society

How this variable changed. All junior and senior students interviewed near the beginning of the study period regarded the role of science in society to be an important one, in contrast with the literature reported in chapter 1 suggesting that young Australians have a poor perception of the role of science in society but in accord with recent reports, also reported in chapter 1, acknowledging an improvement in this perception. Further, the view of the importance of science in society of most junior students, all senior girls, but only one senior boy increased during the study period. The Rating Scale data about the role of science in society, reported in Table 6.17, suggest that the senior boys' views of the importance of science in society were generally high at the beginning of the study period, so a ceiling effect may have been operating.

Why this variable changed. Participation in enrichment and extracurricular science activities was prominent in either broadening students' perceptions about the role of science in society and/or increasing their view of the importance of science in society, although more so for junior students than senior students. For senior students, coursework and the current affairs media each impacted on a similar number of students as did the activities, and these two influences also had some effects on junior students. Other positive influences were library books, considerations related to the deaths of close persons, peers, others outside the school environment, and tertiary course requirements. The only negative factor, affecting one student only, was a dislike of science.

8.3 Summary of Findings for Kinds of Activities

Competitions

Interest, enjoyment, and motivation. Participation in the Australian Schools Science Competition and the National Chemistry Quiz both resulted in overall short-term increases in students' interest and enjoyment in being involved in science activities and/or their motivation to continue to participate in science, most often as a result of students receiving awards. Receiving an award did not guarantee a positive effect, and a positive effect was usually experienced only in conjunction with a student's first entry, unless a subsequent entry resulted in the student receiving either an award for the first time or a higher award. Neither competition provided any negative effects on students' interest, enjoyment, or motivation.

While the Biology Olympiads had no effect on the interest, enjoyment, or motivation of either student who chose to participate, the Queensland School Geology Competition (Senior Division), although having no effects on students' interest and enjoyment, caused a decline in students' motivation towards the further study of geology. This effect was evidently a product of the difficulty of many of the questions.

Scientists. While the National Chemistry Quiz, Queensland School Geology Competition, and Biology Olympiads had no effects on students' perceptions about scientists, the Australian Schools Science Competition did have a first-sitting-only effect of broadening some students' perceptions about the type of work in which scientists can be involved; an effect which was much more pronounced with boys than girls.

Science in society. The first sitting only of the Australian Schools Science Competition broadened some students' perceptions about, and as a result often increased their view of the importance of, the role of science in society. While the National Chemistry Quiz had the same effect but far less frequently (even considering that students had fewer opportunities to sit for it), the Queensland School Geology Competition had no effects on students' views about the role of science in society and the content of the Biology Olympiads did have a positive effect on one student. For ready reference, the effects of competitions on junior and senior students are summarised in appendix 8.A.

Excursions

Interest, enjoyment, and motivation. Seven science activities made a significant positive impact on students' interest and enjoyment in being involved in science activities and/or their motivation to continue to participate in science; the Science Contest Excursion, Planetarium Excursion, *Sciencentre* Excursion, USQ Engineering and Surveying Seminar, Vacation Science Tours, A.S.I.A. Science Summer School, and R.A.C.I. Schools' Lecture. In the case of five activities involving a total of five different students, this effect was also of a longer-term nature. In contrast, the Mine Excursion, CSIROSEC Excursion, and Youth Physics Lecture made little or no impact.

Scientists. The most prevalent effect of excursions on junior sample students was that they broadened some students' perceptions about the type of work in which scientists engage; an effect more significant for the Science Contest, Planetarium, and Mine Excursions and possibly the USQ Seminar than for the *Sciencentre* Excursion. In contrast, the excursions involving senior sample students had, as their major common effect in particularly the cases of the Vacation Science Tours, A.S.I.A. School, and R.A.C.I. Lecture, a negating of the stereotypical image (and associated reinforcement of the normality) of scientists. The CSIROSEC Excursion had this effect on one participant only, while the Youth Physics Lecture had no effects on students' perceptions about scientists.

Science in society. The most common effects of excursions on students' perceptions about the role of science in society were that they broadened some students' views about the contribution of science to society, often also increasing students' views about the importance of science in society. This applied particularly, for junior sample students, to the Science Contest, Planetarium, and Mine Excursions and, in the case of one student only in each case, the *Sciencentre* Excursion and the USQ Seminar. For the senior sample students, this effect was most pronounced for the Vacation Science Tour, A.S.I.A. School, and R.A.C.I. Lecture, with the CSIROSEC Excursion and Youth Physics Lecture having no effects in this area. Appendix 8.B contains a summary, in tabular form, of the effects of excursions on students.

Practical Work

Interest, enjoyment, and motivation. The practical work activities which had the broadest positive short-term effects on students' interest and enjoyment in being involved in science activities and/or their motivation to continue to participate in science were Evening Science, the Investigation (Year 9), Primary Interface, Work

Experience, and the Chemistry Investigation. Very few students experienced negative effects associated with Evening Science and the Investigation. While the Biology Investigation increased the interest and enjoyment of one student only of seven, Science Club had no effect on any of the eight students who participated at some time and the Physics Investigation decreased the interest and enjoyment of one of the seven students.

Scientists. Evening Science, the Primary Interface, and the Investigation all broadened the perception of some students about the nature and variety of the work of scientists, while Work Experience negated the stereotypic image of two girls of the seven students who participated. Science Club and the three senior science investigations had no effects on students' perceptions about scientists.

Science in society. Evening Science, the Primary Interface, the Investigation, and Work Experience broadened the perception of a significant number of students about the role of science in society and, in the case of the latter two activities, this also often resulted in an increase in the view of the importance of science in society. The other practical work activities, Science Club and the three senior science investigations, had no effects on students' perceptions about the role of science in society. Appendix 8.C summarises, in tabular form, the effects of practical work activities on students.

Guest Evenings

Interest, enjoyment, and motivation. Evening Science With a Guest activities increased the interest and enjoyment and/or motivation of 7 of the 10 students (8 junior and 2 senior) who chose to participate, mainly as a result of the topics covered in the case of junior sample students but because it reinforced a future tertiary path in the case of one senior sample student.

Scientists. Participation in Evening Science With a Guest activities influenced the perceptions of 8 of the 10 participants' perceptions about scientists, most often because the evenings broadened students' views about the type of work in which scientists are involved and also, to a lesser extent, because they reinforced or enhanced a student's view about the normality of scientists.

Science in society. Evening Science With a Guest broadened the perceptions of nearly all junior sample students about the role of science in society, also increasing the view of three of the eight junior students about the importance of science in society. There were no effects on the two senior students in this area.

8.4 Conclusions and Implications

Conclusions

This study has shown that, overall, providing both junior and senior students with opportunities to participate in enrichment and extracurricular science activities can increase, at least in the short term, both their interest and enjoyment in being involved in science activities and their motivation to continue to participate in science, change their perceptions about scientists, and broaden their perceptions about the role of science in society and/or increase their view about the importance of science in society. The most prominent activities, in terms of their overall positive effect across all dependent variables (i.e. interest and enjoyment, motivation, scientists, and science in society), were the A.S.I.A. Science Summer School, Evening Science, Evening Science With a Guest, Vacation Science Tours, and the Primary Interface. Note that these are all extracurricular activities and represent excursions, practical work, and guest evenings but not competitions.

The last four of these five activities were designed and implemented by the researcher, who also taught all sample students except Abi at some time during the study period. This raises the question of whether the relative prominence of these four activities is at least in part due to students trying to please their teacher by their responses. While there is no evidence for this (indeed, none was sought as the sample students had left Glendale College some time before this conclusion was reached), the employment of an independent researcher would eliminate this potential source of bias in the results of other studies.

Attention was drawn, in chapter 1, to the need for more Australian students to continue to participate in science. In addition to the five activities identified above, this study shows that student participation in the following activities also made positive contributions towards achieving this goal: the Australian Schools Science Competition, National Chemistry Quiz, Year 9 Investigation, Work Experience, Chemistry Investigation (Year 12), USQ Seminar, RACI Lecture, and excursions to see the Queensland Science Contest entries, to the Planetarium, and to the

Sciencentre. Hence, learning experiences from all four categories of activity motivated students to continue to pursue science.

The result that junior boys were more motivated to continue to participate in science than junior girls for career-oriented reasons may, at first sight, appear to be in accord with Woods' (1979) finding that Year 9 boys had a stronger career orientation than girls. However, all the junior girls acknowledged, at some time, that they found science difficult, compared with only one junior boy. It is possible that career influences were not a factor for most of the junior girls in this study, who may have doubted their ability to cope with the future study of science and therefore not considered continuing to participate in science. This same reasoning may also explain why the Australian Schools Science Competition had a much greater effect on broadening boys' perceptions about the type of work in which scientists can be involved than it had on girls.

Students generally regarded scientists to be highly normal and this finding, particularly for junior students, contrasts sharply with the general finding in the literature that students entering secondary school often hold negative stereotypical views. Thus, negative stereotypic images of scientists which the literature also suggests could contribute to an avoidance of science courses or career choices do not appear to have been an influence in this study.

Little can be concluded from the result that Science Club had no effects on students. Only one junior student, Warwick, chose to participate and five of the six senior participants used this activity simply as an additional opportunity to work on one or more of their senior science investigations, so associated effects are probably reported in conjunction with the latter. The other senior student, Angel, used Science Club to practise chemistry titrations.

Note that the Planetarium Excursion, by allowing Richard to learn much (a cognitive outcome), increased his interest and enjoyment in being involved in science activities (an affective outcome). This supports the suggested link between cognition and affect used in section 2.7 as the basis for including studies with cognitive outcomes in that part of the literature review which dealt with the structure of science activities.

It is recognised that the results of this study are specific to this group of students, partly because it was a sample of convenience (and therefore potentially lacking external validity), partly because it was a longitudinal study and there are additional factors which might threaten internal validity, such as attrition and changing characteristics of the school (even the rural recession and declining student numbers), and partly because some activities, like lectures and guest evenings, are so dependent on the person presenting that one cannot generalise from one activity to the next. For example, while the R.A.C.I. Schools' Lecture made a significant impact on students interest, enjoyment, and motivation, the Youth Physics Lecture had no effect in these areas despite the fact that six senior students attended both. While all these things were out of the control of the researcher, so little was known in the area that a detailed longitudinal study must contribute at least some baseline knowledge that serves two purposes. First, the study gives other teachers some guidance of factors to consider when evaluating the cost/benefit of activities and second, the study provides knowledge that other researchers can build upon.

However, although the findings of this study may not be generalisable to groups of students whose characteristics have not been investigated, the findings may be relevant to similar populations exposed to similar experiences, and so an attempt has been made to provide a sufficiently rich description of the context of the study to allow another person to make a judgement about the transferability of the findings. For example, appendix 3.A provides a detailed description of each activity so that teachers could judge the similarity with their own programs. Also, it is possible that the methodology adopted in this study may have contributed to some exaggeration of the prominence of science enrichment and extracurricular activities in influencing the dependent variables, since each activity undertaken by a student was specifically identified and examined during interview. By making them explicit, this procedure may have given the effects of these activities an advantage in being recognised over other influential factors which were not specifically targetted in this way.

It must be pointed out that the dependent variables measured in this study are not necessarily variables which change dramatically, and the influences of experiences such as enrichment and extracurricular science activities can be long term. While other studies might answer different questions effectively using cross-sectional designs, the longitudinal design employed in this study appears most appropriate in attempting to answer the research questions persuasively, because time is allowed for both short-term and longer-term effects to be realised.

Recommendations and Implications

For teachers. This study has shown that different activities may have different effects on the affect of different students, including longer-term effects, involving nine different students and all categories of activity. It is hardly surprising, but perhaps also somewhat comforting, to find that different things affect different people in different ways. Hence, it is recommended that students be provided with the opportunity to participate in a variety of science activities.

Which activities can be recommended, on a cost/benefit basis (and where cost includes time required of school personnel as well as money), for promotion and/or implementation in schools? This study suggests that, from the point of view of making significant positive impacts on students across all dependent variables (i.e. increasing their interest and enjoyment in being involved in science activities and/or their motivation to continue to participate in science, and influencing their perceptions about scientists and about the role of science in society), the A.S.I.A. Science Summer School is highly attractive. However, while this activity requires minimal input from school staff, the number of students who can attend is limited and each attending student does incur a charge aimed at covering predominantly accommodation costs. For a little more time commitment from teachers, Evening Science and Evening Science With a Guest activities are highly recommended, low-cost opportunities (provided invited guests can be engaged at no, or little, financial expense). Where staff are able to make a greater time commitment, the Primary Interface and Vacation Science Tour are also highly recommended, although the latter can require students to pay for accommodation and bus expenses.

If, rather than seeking influences across all dependent variables, an emphasis was placed on motivating students to continue to participate in science, the Australian Schools Science Competition, National Chemistry Quiz, and Work Experience are readily implemented, low-cost recommendations (although staff time commitments associated with the latter can be considerable, depending upon whether the activity is arranged by students or staff). However, because the junior sample students in this study were a generally able group (8 of these 10 students achieved at an A or B level in their Junior Science course), this recommendation about the positive effects of the Australian Schools Science Competition and National Chemistry Quiz may not transfer to junior student populations in general. Only one student in the junior sample, Kate, could be considered lower-achieving, and the Australian Schools Science Competition had a small positive effect on her motivation in Year 8 only when she was achieving at a C level. Hence, the effects of participation in these competitions on middle- and lower-achieving junior students warrants further research. Also, given the positive influence of students' first entry to these competitions, students achieving in their science studies at a high level (and possibly middle- and lower-achieving students, pending the findings of the research just mentioned) might be strongly encouraged to participate at least once in each competition. Subsequent entries could then be optional, although they will likely impact positively on the interest, enjoyment, and motivation of those students who obtain their first award, or a higher award, as a result of a subsequent entry.

Further, the USQ Seminar, R.A.C.I. Lecture, and Science Contest, Planetarium, and *Sciencentre* excursions have been shown to be motivating influences on students, although each could involve travel costs to students, depending upon where students live. For a greater commitment by staff, the Year 9 Investigation and Chemistry Investigation also motivated students.

There appears to be little for students to gain from entering the senior section of the Queensland School Geology Competition in the form that it took in 1993. In fact, it was the only activity to make a significant negative impact on students; on their motivation to participate further in geology. Suggestions for improving this competition are given subsequently.

It seems that teachers, by encouraging students to adopt a vision or goal for future studies or a career, can facilitate an increase in students' motivation to continue to participate in science in cases where this vision involves science. This study has shown that participation in enrichment and extracurricular science activities can assist in the adoption of such visions and goals by broadening students' awareness of potential science-based careers.

Given the significant positive effect of receiving an award in the Australian

Schools Science Competition or National Chemistry Quiz, which acted as a confidence booster, increasing both junior and senior students' motivation, it is tempting to recommend that awards for outcomes from science activities in general be made available on a liberal basis, but not so liberal as to devalue an award or give students an inflated perception of their aptitude for a subject. However, while awards in both these competitions were made by bodies outside the school, internal awards for the Year 9 Investigation had no effects. It may be that external awards make a greater impact on students than internal awards.

Some suggestions can be made for enhancing the affective outcomes from the Year 9 Investigation. First, a broader range of stimulus material, to assist students with their choice of project, could have been provided. Since these investigations were completed, the Commonwealth Scientific and Industrial Research Organisation (CSIRO) has produced the CREST Awards education program. The program resources, in addition to providing a structure for the carrying-out of a science or technology research project, contain a large number of examples of possible project topics and this program would provide an excellent basis for student investigations. Second, use of a greater number of classroom checks on student progress during their investigations, coupled with appropriate advice, may have encouraged students to make continual progress as opposed to "leaving it to the end" and to avoid unrealistic goals. Third, the negativity associated with the out-of-school time commitment associated with this project could have been reduced by making greater use of in-class time for the conduct of at least part of the investigation and by encouraging students to use (or better use) other in-school opportunities (such as Science Club or Evening Science, in the case of Glendale College).

Finally, a science activity should not necessarily be devalued because it has not been shown, in this study, to have any significant effect on the affective dependent variables. Although not tested here, the activity may be effective in other areas, including the cognitive domain. The Biology and Physics Investigations, for example, were designed to provide students with practice in designing experiments, manipulation skills, data processing, and formal reporting, while the CSIROSEC Excursion provided an opportunity for students to use apparatus and instruments not commonly found in schools.

For other science educators. In light of the literature reviewed in chapter 2, stronger positive outcomes from the Mine Excursion may have been curtailed by two features of the structure of the activity. Passive student participation in a highly structured activity is possibly not as likely to promote desirable affective outcomes as active participation with at least some less-structured opportunities.While the structure of the visit in this study was determined by the hosts and was not negotiable, organisers of future programs for visiting schools might well consider possible ways of incorporating these elements into the visits.

While broadening the perceptions of some students about the type of work in which scientists engage, the Australian Schools Science Competition appears to be missing an excellent opportunity to promote the normality of scientists. This conclusion may initially appear strange, given that students generally reported having a high regard for scientists as being normal people from the beginning of the study period and that changes in this variable would not be expected. However, senior students also said that a major effect of their excursions was that they negated the stereotypical image, and reinforced the normality of, scientists, indicating that their perception of normality at the beginning of the study, while relatively high, had scope for further improvement. Perusal of competition papers confirms this missed opportunity. By including appropriate graphics and text with at least some items on the papers, the competition organisers appear to be in a position to influence positively students' perceptions about scientists in an additional way; similar to the way in which Rennie and Parker (1993) suggest that appropriate language, appeal to background experiences and context, and avoiding the portrayal of stereotypes can produce gender-inclusive physics assessment items relevant to the "real world."

Similar reasoning leads to the conclusion that missed opportunities appear even more pertinent to the potential success of the National Chemistry Quiz, the Queensland School Geology Competition, and the *Sciencentre* Excursion (and possibly the Biology Olympiads, although data are limited here because only two students entered). The National Chemistry Quiz questions, for example, are characterised by an impersonal context. There appears scope for items on these competition papers, and the printed stimulus material supplied at each *Sciencentre* workstation, to be constructed to include opportunities to broaden students' perceptions about the nature and variety of the work of scientists and to negate negative stereotypical images of scientists. In addition to appropriate pictorials and text, the *Sciencentre* workstations might also incorporate some audiovisual material. At the same time, care would need to be taken to ensure that such attempts did not produce test items which were so full of information as to confuse students when identifying relevant from irrelevant information or make the workstations boring.

Despite all students regarding science as having an important role in society from the beginning of the study period, many also experienced an increase in their view of the importance of science in society during this time, with science activities making a significant contribution to this change in perception. However, conspicuous by their little influence on students' perceptions about the role of science in society were the Queensland School Geology Competition, the *Sciencentre* Excursion, and, to a considerable extent, the National Chemistry Quiz. In the case of the National Chemistry Quiz, for example, links between science and society are implied in almost one quarter of the questions, but without the link being made explicit. These activities appear to be missing a valuable opportunity to make a far broader impact on students' views about the breadth and importance of the contribution of science to society. Modification of at least some test items and stimulus materials at workstations along the lines suggested in relation to perceptions about scientists above, aimed at placing them in some form of life-role context which exemplifies the importance of science to our nation's social and economic well-being, appears desirable.

Finally, organisers of any future Queensland School Geology Competition are advised to include further process, or reasoning, type questions in their senior paper, at the expense of questions requiring knowledge which students are unlikely to have. By testing what students can do, as opposed to what they don't know, the competition is likely to influence students far more positively.

For further research. Mention has been made of the need for research about the effects of the Australian Schools Science Competition and the National Chemistry Quiz on middle- and lower-achieving science students. This could readily be achieved via the administration of an appropriately-designed survey form to a relatively large student population.

Many of the activities focussed upon in this study, especially those which broadened students' perceptions about scientists and their work and about the role of science in society, involved real-person contact between students and practitioners in science. Although the effects of these activities were positive, they required considerable teacher preparation time, sometimes a significant cost to students, and were generally labour intensive for presenters (even more so if they were to repeat the activity for groups of students from other schools). Research aimed at determining the comparative effectiveness of cheaper and more time-efficient alternatives such as videos or multimedia presentations aimed at achieving the same objectives could be undertaken. In short, are there any advantages in being on site and/or interacting with practitioners in person? For example, two groups of students could be matched on the basis of their ratings of the importance of science in society. While the students in one group then experience a "live" activity, the students in the other group could experience a pre-recorded presentation. The ratings of students about the importance of science in society could again be sought immediately after each activity. These data could also be supplemented with interview data from selected students from each group, matched on the basis of their pre-activity ratings.

Very little research has been directed towards determining how the way in which an activity is structured and implemented affects outcomes from it, especially affective outcomes and especially for activities other than visits to museums and science centres. This question was not a primary focus in this study, although some suggestions for improving the structure of activities have arisen from it. There appears much scope for comparative studies aimed at determining, for example, the effects of group interaction, the use of worksheets, group reward for individual learning, orientation and previsit strategies, active (compared to passive) participation, and structured (compared to less structured) instruction.

Overall, relatively little research has focussed on the outcomes, both cognitive and affective, from science enrichment and extracurricular activities. This study makes a contribution to filling that void.

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APPENDICES

Appendix 2.A

A Summary of Studies Reviewed About the Effects of Activities on Students

Author	Year	Independent variable	Dependent variable[a]	Participants	Focus on short or longer-term effects[b]	Outcome
Barber, Beard, Moore, & Van Voorhees	1986	Mentoring academy	Career aspirations	Junior-high girls	Short	Positive effects on students' career aspirations involving mathematics, science, and technology.
Bennett	1965	Ecology field trip	Attitude toward science and scientists	Grade 7	Short	No differences in attitudes between field trip and classroom students, but attitudes are not defined. Omitted from literature review.
Borum, Flexer, Casey, & Baum	1983	Visits to two participatory science museums	Interest in learning science	Grades 5 & 6	Short	Increased motivation to learn more about science content displayed.
Bruce, Bruce, Conrad, & Huang	1997	Tutoring by university students	Attitudes toward science	5- to 12-year-old	Short	Project reinforced in many children that they could be scientists too.
De Jager	1992/ 1993	Two-week Space Lab experience	Science-related interests, aspirations, intentions	Elementary	Short	No effects. Abstract does not detail methodology. Omitted.

Appendix 2.A (con't)

Author	Year	Independent variable	Dependent variable	Participants	Focus on short or longer-term effects	Outcome
Diamond, St. John, Cleary, & Librero	1987	Explainer Program (Exploratorium, San Francisco)	Interest in science	Teenagers	Longer	Increase in curiosity and interest of explainers in learning science.
Evans	1992/ 1993	Three-day role model intervention	Attitudes towards science and maths	Grade 9	Short	Attitudes improved, but attitudes not defined in abstract. Omitted.
Fan	1991/ 1992	Science Enrichment Program	Attitudes towards science	Grades 4,5, 9, & 10	Short	Participation made elementary students' attitudes toward science more positive, but these attitudes not defined in abstract. Evidence regarding longer-term effects inconclusive. Omitted.
Finson, Beaver, & Cramond	1995	Career-oriented interdisciplinary program	Perception of persons involved in science	Grade 8	Short	Posttesting "showed far fewer stereotypical images and illustrated a more realistic and broader view" (p. 200).
Finson & Enochs	1987	Visit to interactive science-technology museum	Attitudes towards science, technology, and society	Grades 6-8	Short	Attitudes increased, but are not described. Omitted.

Appendix 2.A (con't)

Author	Year	Independent variable	Dependent variable	Participants	Focus on short or longer-term effects	Outcome
Flick	1990	Scientist in Residence Program	Perceptions of scientists	Elementary	Short	Positive influence.
Fortner & Lahm	1990	Field trip to estuarine reserve	Attitudes toward estuary	Grades 4 & 5	Short	Attitudes improved, but attitudes not those in current research. Omitted.
Gennaro, Hereid, & Ostlund	1986	Five short out-of-school courses for students and parents	Interest in science	Grades 6-8	Short	Increased over one half the children's interest in science.
Gottfried	1980	Visit to *Biolab* (a biology discovery room at the Lawrence Hall of Science)	Benefits to children	School children	Short	The visit was "accompanied by important motivational ... benefits to children" (p. 174).
Hatcher	1992	Junior Zookeepers Program	Attitudes toward science	Students	Short	No significant effect, but ceiling effect could be operating. Attitudes not described in abstract. Omitted.

Appendix 2.A (cont'd)

Author	Year	Independent variable	Dependent variable	Participants	Focus on short or longer-term effects	Outcome
Hofstein, Maoz, & Rishpon	1990	Extracurricular science activities conducted at universities	Interest and enjoyment in science	Junior & senior high school	Short	Activities increased interest and enjoyment but, given the methodology used, this conclusion appears unjustified.
Hughes & Goodlad	1993	Tutoring by college student volunteers	Interest and enjoyment of science	Primary and secondary	Short	Increased students' interest in, and enjoyment of, the lessons with tutors but not science in general. Omitted.
Ignatiuk	1978	Field trip activities	Attitude toward science	Grade 11 Biology	Short	Positive relationship between students' attitudes and exposure to field trip activities, but attitudes as measured do not represent a single construct. Omitted.
Kelly	1988	A number of interventions	Attitudes to science, sex stereotyping, subject choices	11-17 year-old girls	Longer	Omitted, because interventions included experiences in addition to enrichment and extracurricular activities alone.

Appendix 2.A (con't)

Author	Year	Independent variable	Dependent variable	Participants	Focus on short or longer-term effects	Outcome
Kern & Carpenter	1984	Field-oriented approach to an introductory university earth science course	Values, attitudes, interests	University	Short	Omitted, because focuses on interest and enjoyment in the course only and not in science overall.
Krystyn	1986	Participation in Science Talent Search	Interest and involvement in science	P-Year 12	Longer	Successful in increasing interest and involvement.
Lemelle	1992/ 1993	Science and Technology Entry Program	Perceptions towards science	Minority students	Short	Effective in changing students' perceptions, but perceptions not defined in abstract. Omitted.
Mallon & Bruce	1982	Planetarium visit (two types)	Attitudes about astronomy and the planetarium	8-10 years	Short	Attitudes comprise a conglomerate of dependent variables in current research plus others. Omitted.
Mares, Levine, Russell, & Hamilton	1985	Summer Scholars Program	Not applicable	Minority and low-income high school	Short	Strong impact on career confirmation, or narrowing of choice, concerning health sciences careers.

Appendix 2.A (con't)

Author	Year	Independent variable	Dependent variable	Participants	Focus on short or longer-term effects	Outcome
Olson	1985	Participation in North Dakota Science and Engineering Fair	Career choice	Finalists	Longer	Participation appears to have influenced career direction, education, and employment.
Parks	1985/ 1986	Museum instructional program on dinosaurs	Attitudes toward learning about science, the museum, and palaeontology	Grade 6	Short	No effects on attitudes. These attitudes are not defined in abstract. Omitted.
Reed	1975	Use of a planetarium learning environment	Enrolment in astronomy course	College students	Short	Planetarium very strongly influenced enrolment in astronomy course.
Ridky	1973/ 1974	Planetarium instruction	Astronomy perceptions	Junior high school and college	Short	Although positive change in astronomy perceptions in both groups is reported in abstract, perceptions are not defined. Omitted.
Saeger & Valesky	1984	Health Careers Opportunity Program	Enrolment in science-related coursework	Minority students	Short	Program increased enrolments, but this conclusion questioned (see section 2.6).

Appendix 2.A (con't)

Author	Year	Independent variable	Dependent variable	Participants	Focus on short or longer-term effects	Outcome
Silverman	1985/ 1986	Participation in Science Fair	Interest in science	Grades 7-9	Short	Increased science interest.
Smith & Erb	1986	Exposure to female science career models, reading about women in science	Attitude towards scientists and women in science	Grades 5-8	Short	Treatment students had more positive attitudes towards scientists and towards women in science.
Sneider, Eason, & Friedman	1979	Visit to *Star Games* exhibit (Lawrence Hall of Science)	Interest in learning more about telescopes and astronomy	High school	Short	Conflicting findings. No change in interest when books used as part of posttest instrument, but increase in interest reported in pilot study using posters.
Stronck	1983	Visit to natural history exhibit, British Columbia Provincial Museum	Desire for further study	Grades 5-7	Short	Neither the more-structured nor the less-structured tour affected student's desire to study about animals.

Appendix 2.A (con't)

Author	Year	Independent variable	Dependent variable	Participants	Focus on short or longer-term effects	Outcome
Swindell & Phelps	1991	Science enrichment program	Attitudes towards science	Disadvantaged and minority high school females	Short	Although increased interest in science is reported, attitude test items/instrument not given. Omitted.
Williams-Robertson	1990	Science Academy Summer Institute	Interest in science	Middle school students	Short	More than one half the participants showed increased interest in science.
Woolnough	1993	Nature of school (resources, staffing, curriculum)	Choice of science and technology courses in higher education	Sixth-form students	Short	Existence of extracurricular science activities correlated highly with higher education enrolment in a physical science or engineering.

[a]Some studies had more dependent variables than are listed here. Only those variables relevant to this study are shown. [b]Longer-term effects are those which are present about 1 year or longer after participation in an activity.

Appendix 3.A

Descriptions of Enrichment and Extracurricular Science Activities

This appendix contains a description of those activities listed in Table 3.A in which at least one sample student in this study chose to participate.

Australian Science Competition

The Australian Schools Science Competition is an annual national competition conducted by the Educational Testing Centre, The University of New South Wales and administrated in schools by teachers. Different papers are prepared for each of Years 5 to 12, and Years 8 to 12 students are asked to answer 45 multiple-choice items in 1 hour. Students from each Australian State are marked as a separate population and the following awards are made:

High Distinction (HD)	:	top 1% of entrants in the State
Distinction (D)	:	next 10% of entrants in the State
Credit (C)	:	next 20% of entrants in the State
Achievement (A)	:	students who placed in the top 20% of their school but did not qualify for a State award.

A small entry fee is charged.

Science Contest Excursion

Before the visit. During the week prior to the excursion, each student was given a workbook which contained the aims of the excursion (both cognitive and affective), a plan of the venue (the Queensland Museum), and the tasks to be completed. Students also viewed an introductory video of the museum. It was intended that students peruse a range of permanent exhibits during their visit and also focus more closely on the science contest entries which were similarly set up as exhibits.

During the visit. Upon arrival at the venue and use of the rest rooms following a 2-hour bus trip, students were given a 15-minute introductory lecture, by a museum staff member in the Lecture Theatre, about the role of the museum. They then spent about 20 minutes exploring the museum's exhibits, which included entries in the 1992

Queensland Science Contest, spread over a number of floors. Museum staff were available to answer questions. During this exploratory time where, as for the rest of the visit, students were free to work either as individuals or in small groups, students were asked to identify each floor level and to name at least three displays on each level.

The main student task during the next 2 hours 10 minutes was to study the contest entries, which included experimental research, classified collections, models and inventions, computer-based entries, and a general category for other entries such as videos, charts, and library-research projects. Students were required to peruse the exhibits, list the categories (and divisions) into which the entries had been divided, give the titles of at least six entries in each category, and, after choosing two different types of entry from the same category for more detailed analysis, to take sufficient notes to allow them to write an essay, for homework, which summarised both entries. However, students were encouraged to break this time into shorter segments by taking periodic strolls through the other museum exhibits and choosing an appropriate morning-tea interval.

After the visit. Students travelled a relatively short distance to the Sir Thomas Brisbane Planetarium (the afternoon excursion venue on the same day) and had a picnic lunch. For homework (over a couple of nights) students were asked to write their essay and complete a short written student evaluation of the excursion.

Planetarium Excursion

This visit to the Sir Thomas Brisbane Planetarium occurred on the same day as, and following, the Science Contest Excursion described previously. During the week prior to the excursion, each student was issued with a workbook which contained a plan of the planetarium, Foyer and Gallery Worksheets (supplied by the planetarium), and a list of items for sale at the venue. Following a 30-minute period of time spent completing the Foyer and Gallery Worksheets, students viewed a 45-minute Star Theatre Show, a presentation which comprised ceiling projection and commentary. They then travelled home for 2 hours and were asked to complete a short written excursion evaluation for homework.

Mine Excursion

Before the visit. During the week prior to the excursion to Ebenezer Coal Mine, Rosewood, Queensland, students were given a workbook which contained the aims (both cognitive and affective) of the excursion, a 43-item written questionnaire, and homework requirements. Most questions on the questionnaire, which was completed by students during the course of the excursion, required the filling-in of a blank space with phrases. On the morning of the excursion, students travelled for 1 hour 15 minutes, by bus, to the venue.

During the visit. A female mine employee boarded the bus and provided a commentary as the open-cut facilities were toured. During this time, students also attempted to respond to the questionnaire. At the end of the 45-minute tour, students were invited to leave the bus and collect a sample of coal and were also issued with some mining brochures. Teachers took a short time to address students' queries about, and responses to, the questionnaire.

After the visit. Students travelled 30 minutes to lunch at a McDonalds (fast food) outlet before heading off to the Queensland Museum *Sciencentre*, venue for afternoon excursion activities. One homework option was to write an account (300-400 words over three nights) of the mine visit, including interesting features of the mine and details about how it operates. (The other homework option related to work at the *Sciencentre*.)

Museum Excursion

During the week prior to the excursion, each student was given a workbook which contained a timetable for excursion activities and worksheets relating to three static displays at the Queensland Museum. Upon arrival at the venue and use of the rest rooms following a 2-hour bus trip, students were given a 15-minute introductory lecture, by a museum staff member in the Lecture Theatre, about the role of the museum. They then spent 1 hour 30 minutes rotating through the three displays and completing the worksheets. After the visit, students walked a distance to the Queensland Museum *Sciencentre* (the venue for the afternoon excursion on the same day) and had a picnic lunch. Their workbooks were handed in for marking and, for homework, students were asked to complete a short evaluation of the activity.

Sciencentre *Excursion*

This excursion to the interactive Queensland Museum *Sciencentre* occurred during the afternoon following either the Mine Excursion (Year 9 students, 1993) or the Museum Excursion (Year 9, 1991). During the week prior to the excursion, students were given a workbook which contained a plan of the *Sciencentre* and a list of activity stations. Upon arrival at the venue and following some introductory 20-minute demonstrations by a female explainer, students spent 1 hour 30 minutes exploring the hands-on workstations on each of three floors. Each exhibit was typically accompanied by instructions and explanation. Students were free to choose to work as individuals or as a member of a small group. After the visit, students departed for a 2-hour bus trip home. For homework, they completed a short excursion evaluation and Year 9 students in 1993 were asked to complete a report about either this activity or the morning Mine Excursion.

Investigation

Every Year 9 Junior Science student was asked to complete, during a 6-month period, an individually-designed practical scientific investigation of their own choice in one, or a combination of, three categories: experimental, invention, or collection. While most students worked on this project in their own time, they had the opportunity to use Science Club, Evening Science, or laboratory equipment at any other convenient time by arrangement with a teacher.

Each student was given an introductory handout which contained a description of, and example project titles and requirements for, projects in each category, together with details of how to reference the contribution of others, examples of similar projects completed by other students (including both previous students of Glendale College and award-winning students from other schools), an invitation to enter their work in external competitions, and a description of the internal certificates awarded:

Certificate of Distinction (D) : for work of a high standard

Certificate of Achievement (A) : for satisfactory work.

Students receiving a Certificate of Distinction also received a prize such as a CSIRO T-shirt or Double-Helix cap. (These certificates and prizes were available to Year 9 students, for the first time, in 1993.)

A.S.I.A. Science Summer School

This 3-day school was conducted, at a tertiary institution, by the Australian Scientific Industry Association (A.S.I.A.), in association with Rotary Clubs, tertiary institutions, and industry. Participating students, after selection via their local Rotary Club, met and listened to distinguished scientists and engineers, watched and performed experiments, participated in team competitions, joined in discussions, received advice on career opportunities, and toured research laboratories, manufacturing plants, or other places of scientific interest. The cost of about $50 per student predominantly covered accommodation.

National Chemistry Quiz

The National Chemistry Quiz is an annual competition, conducted by the Royal Australian Chemical Institute and administered by teachers in schools. The competition aims to promote an awareness of both the importance of chemistry to the community and the role of chemistry as a profession. Four different papers are prepared each year (Years 7 and 8, Years 9 and 10, Year 11, and Year 12) and students are invited to answer 30 multiple-choice questions in 1 hour. A small entry fee applies. Awards are made at the following levels:

Excellence (HDEX)	:	Score of 100%
High Distinction (H)	:	Top 10% of State
Distinction (D)	:	Next 15% of State
Credit (C)	:	Next 15% of State

In addition, the top couple of students in each State receive a plaque as an Award of Excellence.

USQ Seminar

The USQ Engineering and Surveying Seminar was a free, annual, 1-day program, conducted by the Faculty of Engineering and Surveying of the University of Southern Queensland, for Year 10 students. Following an introductory lecture and video, students worked for the remainder of the day in small groups on activities involving measurement of the speed of a bullet, distance measurement, timber fabrication and testing, computer aided drafting, the strength of steel, a people counter, concrete ice creams, paper bridge construction, vibrations, hydraulics, and soil strength testing. During meal breaks, students could interact with both peers and members of staff.

Primary Interface

Volunteer Year 10 students prepared, in their own time over a few weeks and under the supervision of the Head of Science (the researcher), an approved scientific demonstration of either their own choice or one supplied by a teacher. They then performed the demonstration, in pairs, for visiting primary school students. During the demonstration, they asked questions of, and provided explanations for, the visitors. Each volunteer received a Certificate of Participation.

Biology Olympiads

The National Qualifying Examination of the Biology Olympids is conducted by the Australian Science Olympiads organisation and administrated in nominating schools by teachers. The examination is free, requires typically Year 11 students to answer 50 multiple-choice and 4 written-response questions in 2 hours, and constitutes the first of five steps in the process of having a team of students represent Australia in the International Biology Olympiads.

R.A.C.I. Lecture

The 1993 R.A.C.I. Schools Lecture *Chemistry: The Problem Solver - Old Bones Wrapped in Plastic* formed part of the annual series of lectures conducted by The Royal Australian Chemical Institute (Qld.). Presented by two male tertiary personnel, the lecture comprised a number of demonstrations involving the dating of bones and the physical and chemical characteristics of plastics and polycarbonates. Students also received a bookmark and sticker.

Queensland School Geology Competition

A multiple-choice test, for each of a junior and senior division, was produced by the Geological Society of Australia Incorporated (Qld. Division). The senior paper invited students to answer 50 questions in 1 hour. Certificates were awarded on the following basis:

High Distinction (HD)	:	67% - 100%
Distinction	:	55% - 67%
Credit (C)	:	39% - 55%
Participation (P)	:	0% - 39%

Work Experience

A student performed voluntary work, with an employer of their choice, during a vacation period.

Biology Investigation

To prepare students to design and conduct an experimental investigation of their choice, each student was given an introductory handout containing purpose, topic areas to select from, general steps to be completed, proposal sheet, and marking scheme. The proposal sheet, used to seek permission to conduct an investigation, asked for title, aim, resources used/needed, and procedure.

Students conducted their investigation, either individually or as a member of a small group, using seven periods (each 50 minutes) of timetabled time plus their own time. They could order required materials from the Scientific Assistant. Students then submitted an experimental report and certificates were subsequently issued, from 1995 onwards, for work of a very high, high, and satisfactory standard.

Chemistry Investigation

Students received an introductory handout for this individual, student-chosen and student-designed experimental investigation containing an overview of requirements (including prior library research), examples of topics and approaches to investigation, and marking criteria. After receiving permission to conduct their proposed investigation, each student used 12 periods (each 50 minutes) of timetabled time, plus their own time if necessary, to carry out their work before submitting a written report (maximum length 12 pages). During their investigation, students could order materials from the Scientific Assistant. Certificates were issued, from 1995 onwards, for work of a very high, high, and satisfactory standard.

CSIROSEC Excursion

The global aim of this activity was to allow students to work, at the CSIRO Science Education Centre, Brisbane, on a number of structured physics experiments which used equipment not normally available in secondary schools. Prior to the excursion, students were given a handout which contained specific aims, timetable, structure of the excursion, and a worksheet (supplied by the Centre) for each available activity. Students, grouped in pairs, made group-specific choices of a number of activities, read the introductory material for each chosen experiment, completed the corresponding pre-visit activities, and perused the instructions for conducting each experiment.

Following a 2-hour bus trip to the venue, students explored the laboratory environment for about 15 minutes before settling down to work in pairs, over some 3 hours 30 minutes including morning and afternoon tea breaks and excluding a 1-hour luncheon break, on their chosen experiments. This work included the completion of the worksheets for each experiment. To conclude the visit, students watched a series of demonstrations, occupying about 20 minutes, performed by a female staff member of the Centre. For homework, students were asked to complete a brief evaluation of the excursion.

Physics Investigation

This activity required students to complete an individual, practical investigation involving experimental research, the construction of an invention, or a combination of these. Students were initially issued with a booklet (Eastwell, 1988) containing advice about the required steps (i.e. choosing, designing, and carrying out an investigation, analysing results, and writing formal reports), together with some examples of investigation titles and a checklist-type worksheet. Students were also given a copy of the assessment criteria. The checklist formed part of the approval mechanism for each student's investigation and asked students to state the problem or question they intended to investigate and the status of their literature review, together with an outline of procedures to be adopted and their proposed time-line.

The work was carried out over a 6-month period, using one period (50 minutes) of class time each week plus any of their own time that a student chose to spend on the project, and culminating in the submission of a formal written report. Students were encouraged to enter their work in external competitions, and certificates were issued for work of a very high, high, and satisfactory standard. (In 1994, final-round interviews were conducted with Year 12 sample students before certificates were issued.)

Youth Physics Lecture

The 1-hour 1994 Youth Physics Lecture, titled *Using the Second Law to Squeeze Light Into Museums, and Demonstrations of Energy Transfer Processes*, was one of a series of annual lectures organised by the Australian Institite of Physics (Qld). The male presenter outlined the second law of thermodynamics in its various forms and showed how it governs many of the exotic and everyday aspects of our world and our lives. He then used its application in the design of systems to improve illumination in buildings (a current applied physics research area) to demonstrate the usefulness and pervasive nature of this law.

The mood then lightened, with various energy conversion processes illustrated by simple but spectacular demonstrations, most of which were governed by the best known form of the second law, Murphy's law. The lecture was about equally divided between lecture and demonstrations, with questions from, and participation by, students invited.

Science Club

This was a formally timetabled activity (one 50-minute period each week) during which students could undertake any one or more of a variety of practical science activities of either their own choice or design or supplied by the female supervising science teacher.

Vacation Science Tour

This annual 2-day bus tour for students and interested parents and/or assistant supervisors was organised by the Head of Science (the researcher) and conducted during the first week of the December vacation. The tour involved visiting a number of predominantly Brisbane locations (typically four each year) to observe and discuss science being applied in the community and to broaden students' awareness of career opportunities in the sciences, as well as opportunities for some day shopping and evening entertainment.

Prior to the excursion, students received a handout which contained background information about Australia's needs in science and technology, aims of the trip, a program outline, accommodation details, a timetable, and other miscellaneous details about the tour. The following exemplify the venues visited and the topics discussed: Heron Pharmaceuticals (manufacturing processes, course pre-requisites); John Tonge Centre (forensic biology); Queensland University of Technology (optometry); Incitec (ammonia and urea manufacture, soil analysis); CSIRO, Long Pocket (genetic engineering and production of vaccines); Royal Australian Air Force, Amberley (technical work); Hydrometallurgy Research Laboratories (mining research); CSIRO, St. Lucia (tropical crops and pastures); Total Peripherals (computing); Queensland United Foods (manufacturing, packaging); Queensland Police Department (forensic science); and Royal Brisbane Hospital (radiography). At the end of the tour, each student completed a brief tour evaluation and received a Certificate of Participation.

Evening Science

Students were invited to use the College's science facilities, which were opened for 1 hour 30 minutes after dinner one evening each week under the supervision of the Head of Science (the researcher), or to seek tutorial assistance from him during this time. Typically, students chose to use computer software, repeat class experiments, perform other experiments, unpack and set up new apparatus, and use Lego materials.

Evening Science With a Guest

On about four occasions each year, a small group of students and the Head of Science (also the researcher) was joined by an invited guest presenter for dinner at the college, followed by a presentation and discussion in a science laboratory. Guests were mainly locals involved in scientific enterprises which included cereal chemistry (Peter Walsh), flora and fauna research (Tom Kirkpatrick), insect control and field ecology (Stephen Sexton), sorghum breeding (Bob Henzell), electrical engineering (Lyn Brodie), weather-satellite imaging (Phil Webb), mass spectrometry and scientific instrumentation (Gary Young), and veterinary science (Sid Miller). There was one female guest only; Lyn Brodie. These guests also formed part of a pool of student mentors (persons who had indicated their willingness to assist interested students with their scientific investigations) kept by the Head of Science.

Hermitage Visit

One afternoon a short time following the Bob Henzell Evening Science With a Guest activity which focussed on sorghum breeding, a small group of interested students were transported by the Head of Science (the researcher) a relatively short distance to the Hermitage Research Station, Warwick, to observe a demonstration of how to cross-fertilise sorghum.

External Science Competitions

Although many opportunities existed for students to enter their work in external competitions, the only one relevant to this research report is the Queensland Science Contest, conducted annually by the Science Teachers' Association of Queensland. The contest is for student work in any of five categories (experimental research, classified collections, models and inventions, computer, and general) and was judged in four age divisions. Winning entrants are presented with cash or trophies during a presentation evening.

Appendix 3.B

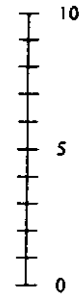
Student Survey

Name: --- Date: --------------

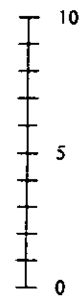
Year: --------------

1. Please use a cross (X) to rate each of the following on a 0 - 10 scale. (0 is the lowest, 10 is the highest)

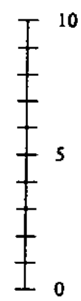
(a) Your interest and enjoyment in being involved in science activities.



(b) Your motivation to continue your study of science.



(c) Your view of the importance of science in society.



2. How likely is it that you will stay at this college until the end of Year 10? Place a cross (X) in one box only.

Very likely	Not sure	Probably not

Appendix 3.C

Course Interest Survey

For each statement, place a cross (X) in the square that agrees best with your opinion.

Key:

5 = all of the time
4 = most of the time
3 = some of the time
2 = not very often
1 = never at all

1.	I look forward to science classes.	5	4	3	2	1
2.	I enjoy the homework and study associated with science.	5	4	3	2	1
3.	I enjoy my work in the classroom.	5	4	3	2	1
4.	After a science lesson I usually feel a sense of satisfaction.	5	4	3	2	1
5.	I would recommend science to future Year 8 students.	5	4	3	2	1

Appendix 3.D

Extracurricular Science Activities: Year 8

Our college offers Year 8 students the opportunity to participate in a range of extracurricular science activities. These activities are optional, and include the following:

Science Club.

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Vacation Science Tour.

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Tuesday Evening Science (experiments, tutorials).

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Tuesday Evening Science with a guest.

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Circle the activities that you have participated in and write, in each of the spaces provided, your reasons for choosing to participate in each activity.

Write, in the other spaces, your reasons for not participating in each activity.

Appendix 3.E

Demographic Data

Name: -- Date: ----------------

1. What is your date of birth? . . . .

2. Are you, or have you been, a day student or a boarder? Explain where necessary.

. . . .

. . . .

. . . .

3. What are the occupations of your parents?

. . . .

. . . .

4. Where do you fit in your family (e.g. only child, second youngest of four children).

. . . .

. . . .

5. Have you previously attended another secondary school? If so, please give details.

. . . .

. . . .

. . . .

6. Describe your primary school background.

. . . .

. . . .

. . . .

Appendix 3.F

Year 10 Interview Schedule: First Round

Preliminary

Give each student a copy of the handout *Focus of the Interview: Round 1* (appendix 3.G) at least 1 week before the interview.

Have tape recorder covered as much as possible to reduce its obtrusiveness.

Introduction

"We are trying to improve our science courses. In particular, we are interested in the effects of special science activities on students. I am pleased that you are willing to help because your thoughts could improve the science education of future students of the College.

Do you mind if we put some of what you say on tape, saving me having to take notes as we go?"

Checklist

1 Time of arrival at this College?

2 List Year 10 enrichment and extracurricular science activities participated in.

3 Repeat for Years 8 and 9 activities at this College or previous school.

4 List science subjects you intend to study in Year 11.

Rating Scales

1 Invite students to rate their interest and enjoyment in being involved in science activities on a copy of a *Rating Scale* survey (identical to section 1 of appendix 3.B).

Stress to students that none of the questions during the interview are in any way a test. "Please be honest about your feelings because only honest feelings will help us in our study. Even negative feelings are welcome; they won't be held against you. Your views will not be used for any purpose other than this research."

2 Student rates their motivation to continue their study of science on the *Rating Scale* survey.

3 Turn tape recorder on.

4 Ask students about their career possibilities/views.

5 Ask students about their view of/description of scientists (as people, their characteristics [including gender], what they do).

6 Students rate their view of the importance of science in society on the *Rating Scale* survey.

7 Ask students about their view of the role of science in society.

Consider each activity in turn

Each activity was addressed, in turn, in the following way.

1 Remind/question student about what was involved. (For activities such as Evening Science and Club, where the type of activity may differ between students, ask students to describe their activity.)

2 "Have you been there/done this activity before?"

3 Cover each of the *Four Key Areas* outlined below. Look for negative as well as positive effects.

Four Key Areas. "What effect [seek changes], if any, did this activity have on your:

(a) interest and enjoyment in being involved in science activities, in general?" (Describe magnitude of change as a little bit, a medium bit, or a lot.)

(b) motivation, or desire, to continue your study of science (that is, later on, past Year 10 or past Year 12)? Did it spur you on or put you off?" (Describe magnitude of change as a little bit, a medium bit, or a lot.)

"Has this activity had any effect on your senior subject choice decisions? Would you have chosen these senior science subjects anyway? Who and/or what contributed to your senior science subject choices?" (May need to consider each subject in turn. Do this in conjunction with first activity only.)

(c) view of scientists (as people/what they do)?"

(d) view of the role (place) of science in society (our lives)?"

4 "What other effects, if any, has this activity had on you (that we haven't discussed/that you think I might be interested in)?" (In the case of an award, ask about the effects the award has had on the student.)

"Any other feelings about the activity, either positive or negative?"

At the End

"After I go through the tape, I will get back to you about any extra information or clarification which may help."

Invite students to let me know, at any time, if anything further related to the matters discussed comes to mind.

Remind students that I will have another chat with them at the end of next year, looking at the effects on them of Year 11 activities.

Thank the student for their assistance.

Appendix 3.G

Focus of the Interview: Round 1

Your description of:

(a) your view of scientists, and

(b) the role of science in society.

The effects of special science activities (e.g. excursions, competitions, and guest evenings) on your:

(a) interest and enjoyment in being involved in science activities,

(b) motivation to continue your study of science,

(c) view of scientists, and

(d) view of the role of science in society.

Appendix 3.H

Sample Interview Transcript: Alec, Year 10 (Round 1)

Career Thoughts

Interviewer (I): Alec, what career possibilities or views do you have in mind at the moment?

Respondent (R): Um, just architecture or civil engineering but possibly behavioural science.

I: Ah, right. What does behavioural science involve?

R: Well, I'm not really sure.

I: Maybe psychology?

R: Yeah. I'm sort of interested in psychology, behavioural, anything but also maybe probably not a doctor or a G.P. but maybe something in the medical but probably just architecture so far.

View of Scientists

I: O.K.. I'm interested in your view at the moment of scientists; your view of scientists as people, their characteristics, or what they do. What comes to mind when someone says a scientist?

R: Um. Probably some kind of genetic engineering or genetics.

I: Ah ha. Any particular characteristics come to mind?

R: Um.

I: When you think of a scientist?

R: Probably I generally think of them as, um, reasonably intelligent or very intelligent, usually older people but with younger people studying with them or participating in whatever experiments they are in.

I: Hm-hm.

R: Hum, usually unmarried and kind of, lead a solitary life.

I: Good. Any other characteristics come to mind?

R: Um.

I: The type of people they are?

R: Well I think the type of person that they would be would be the very inquiring and, depending on what branch of science they're in they'd be very interested in either cosmos or genetics depending on as I said what branch they're in and probably fairly eager to learn or excited by anything new.

I: Any comment about gender?

R: Ah, I don't really think so, not any more. Scientists seem to be pretty much both sexes.

I: O.K. Anything else come to mind about the characteristics of scientists as people?

R: Ah.

I: Or the work they do?

R: Most of, it seems to me that most of the, um, important or more important discoveries have occurred earlier in the century or in the 1800's. There seems to be less, um, achievements being made nowadays that are so hard-hitting. They might be hard hitting in 10, 20 years time except right now most of the experiments they are doing do not affect me at all whereas some of the ones like Madam Curie did with the x-rays.

I: Anything else about your view of scientists?

R: No, I don't think so.

I: O.K.

(Rating Scale [c] marked)

Role of Science in Society

I: Can you tell me something about your view of the role of science in society?

R: Well, the medical branch of science I feel is reasonably important, to develop new vaccines, new healing techniques, to try and cancel out some of the more major illnesses around. The sciences of physics, chemistry are reasonably important. Physics and chemistry, I feel, are more concerned with the long-term well-being of the population or of a particular species and can be of more use in, um, well just developing something new that's essential and not in any kind of healing or things like that.

I: O.K. Any other feelings about the place of science in society?

R: Um. No, I don't think so. It's, well, society does centre around sciences because any new achievements or developments are generally hard-hitting.

I: Right.

R: And do affect the population fairly violently. If not violently, decisively.

I: Any other views on the place of science in society?

R: No. No more.

I: Let's take each activity in turn. Let's look at the Australian Schools Science Competition first.

R: O.K.

Australian Schools Science Competition

I: What effect, if any, did doing those competitions have on your interest and enjoyment in being involved in science activities?

R: Well they increased it probably a lot because of the fact I have done well in them or reasonably well so that makes me feel like I've accomplished something and that I can do the science subjects so it motivates me a bit more to go and study harder and longer.

I: O.K. That was going to be my next question, ah, your motivation. Do you think it has increased a little bit, a medium bit, or a big bit as a result of doing those competitions?

R: Probably a medium bit.

I: Right.

R: They've just helped me, stick it, stick at it and work harder.

I: Are there any other reasons for those competitions increasing your interest and enjoyment?

R: Um.

I: In being involved in science activities?

R: Not really. I just, I do well in them so I, get enjoyment from 'em.

I: O.K., Any other reasons for them increasing your motivation?

R: Um, no, again, I've pretty much stated it.

I: Did doing the Australian Schools Science Competitions have any effect on your subject-choice decisions?

R: Hm, probably not much as they're not divided into the physics, chemistry, and biology sections so I feel that my subject choices were more from my interest in the actual subjects, the enjoyment of them, the usefulness in later life and the, um, way in which we participate in them.

I: Had you not done those competitions do you think you still would have chosen those two sciences?

R: Yes. I think I would have chosen those two sciences still.

I: So, did the competition have any effect?

R: No, not directly except it's just increased the interest level and produced an attitude that I can do science and therefore I will.

I: Any effect on not choosing Biology?

R: Um, no. The reason I didn't do Biology was just because it didn't fit onto my lines properly. ["Lines" refers to the timetable]

I: O.K. Which other subject do you get there?

R: Ah, I want Art to become an architect.

I: Did doing the Australian Schools Science Competitions affect your view of scientists?

R: Ah.

I: In any way.

R: Yes, it showed me that they analyse data a lot more than they did experiments. I mean they still did experiments except the experiments which they do are a lot different to what is imagined by the most, by most people. And the competitions just showed me information which I had to analyse, just pick out, I feel that they do more of that than the experiments that people think they do.

I: So, those competitions you're suggesting, have changed.

R: Yes, they've changed my attitudes to science and they've helped quite a lot in the motivation area.

I: Right, what about your view of scientists? How have they affected your view of scientists?

R: Well they've stopped them being the outlandish more way-out type of person and brought them down to a more down-to-earth type of person except I still think of them as probably more solitary and they, I think they would have a keenness to know new things and be excited by anything new they develop or discover.

I: What, what aspects of the science competition led you to think that way?

R: Well, probably the, can't really say any particular section. It's just the, probably the harder questions that gave you the information that told you you had to analyse it and determine the following things from it.

I: O.K., so had you not done the competition, do you think your view would have been?

R: [Interrupts] Um. I think I would have thought scientists to be very seclusive and, um, a little bit more haphazard and forgetful, not really like a real person.

I: O.K., has doing those competitions changed in any other way your view of scientists?

R: No. I think I've pretty much stated it all.

I: Either as people or what they do?

R: No. No more.

I: Have those competitions had any effect on your view of the role of science in society?

R: Um, well they've shown that science can change a lot of things and determine them. Um, except, I still think of science in society as the, ah, backbone for new developments and any kind of improvements in living. I don't think it's changed my view of science in society.

I: Not at all?

R: Ah, maybe a little but in no particular way.

I: You can't think of any specific example of the way in which your view.

R: No.

I: Of the role of science in society, the place of science in our lives, has been changed by doing those tests?

R: No, not really.

I: O.K., has doing the Australian Schools Science Competitions had any other effects on you that we haven't discussed and you think I might be interested in?

R: Um. No I think you've, um, asked most of the right questions and I can't think of anything more.

National Chemistry Quiz

I: O.K.. Well let's leave that one and move on now to the National Chemistry Quiz.

R: Hm hm.

I: You've only done that one this year?

R: Yes. It's only open to Years 10 and 12.

I: What effect, if any, did doing that chemistry quiz have on your interest and enjoyment in being involved in science activities, in general?

R: Um, in general, I don't think it increased it much because the, work in it I feel was reasonably basic and, although I did well in it, and it interest [*sic*], and it gave me motivation, it didn't increase it much.

I: O.K. Any increase at all in your interest and enjoyment as a result of doing that test?

R: Probably a small amount, except.

I: Little, medium, or big?

R: Probably anywhere between little and medium.

I: O.K.. For any particular reason?

R: No it just sort of, it changed it slightly, and [pause].

I: Changed what?

R: It changed my [pause].

I: Interest and enjoyment?

R: Yeah, it just changed my interest and enjoyment and allowed me to think more clearly, which has boosted up my interest.

I: Did doing that quiz have any effect on your motivation to continue your study of science later on?

R: Um, ah, probably a medium amount because it was more directly involved with the chemistry, and again I did well in it, and I feel that it's just helped generally increase my interest in chemistry, a small amount.

I: O.K.. Ah, do you think it's motivated you a little bit, a medium bit, or a big bit?

R: Probably only a little bit this time.

I: O.K.. Motivated you in what area?

R: Probably the continuation of study in chemistry, area.

I: O.K.. Did that National Chemistry Quiz have any effect on your subject choice decisions?

R: Um, no, not really. Not at all probably.

I: Would you have chosen these subjects anyway?

R: Yes, I think so.

I: Who or what contributed to these senior science subject choices?

R: Um, probably my interest level, the, ah, the need for them in later life, um, the, in chemistry the more exciting things happen with the experiments and the hands-on.

I: Hm hm.

R: And, except I don't think anyone in particular sort of aided except maybe my brother because he did them and found them reasonably easy and could do well in them and I think therefore I could.

I: What do you mean by might need chemistry or physics in the future?

R: Well, uh, for University if I want to go on to become a civil engineer I will need the chemistry physics, and, that will just let me get into that, to pursue that career.

I: O.K., Alec, did doing the National Chemistry Quiz have any effect on your view of scientists?

R: Um the chemistry quiz didn't really have much of an effect on my view, on scientists, because my view hasn't changed before or after I've done it, so, it hasn't really changed it at all.

I: Um, not as people or, or the work they do?

R: Nuh. It hasn't really changed any of my attitudes.

I: O.K.. Has the National Chemistry Quiz had any effect on your view of the role of science in society?

R: Um. Once aga [*sic*], once again no it hasn't changed it really.

I: No effect there on.

R: The place of science in society?

R: No change.

I: Has the National Chemistry Quiz had any other effects on you that we haven't discussed and you think I might be interested in?

R: Mmm, no except it give, it did give me a sense of achievement so therefore

I guess, it sort of encouraged the continuation of chemistry.

Science Club

I: Well let's go back now to Year 9. You said you did Science Club for one session.

R: Yeah.

I: Can you tell me a little bit about what you did during Science Club?

R: Um, in Science Club I did, mainly did chemistry experiments, just basic, except I did a couple of physics experiments with some of the, um, technique, just to find out some of the pulleys and ratio except, um, Science Club was pretty relaxed.

I: O.K., anything else?

R: No.

I: Did that one session in Science Club have any effect on your interest and enjoyment in being involved in science activities?

R: No. As I said it was reasonably relaxed so it was sort of a easy-come easy-go type of Club.

I: So.

R: It might have helped more if I'd been either having difficulty with science or, I had an exam coming up like an end of year where I could study for it and gain help where I didn't understand it. So because it was right at the beginning it sort of was a bit, reclusive just, there at the end of the week. It was fun and enjoyable but, didn't really change overall my interest level.

I: Or enjoyment in being involved in science activities?

R: No.

I: O.K.. Do you think Science Club had any effect on your motivation to continue your study of science later on?

R: No I don't think so.

I: Do you think Science Club had any effect on these subject choices that you've made recently?

R: Um, once again I don't think so. It was a very, sort of easy-going, sort of Club, so.

I: Did Science Club change in any way your view of scientists, either as people or what they do?

R: No, not really.

I: Did Science Club have any effect on your view of the role of science in society?

R: No, once again I didn't really learn much overall from the Science Club. It was more an easy.

I: An easy?

R: An easy sort of, way, to learn a bit and discover something I didn't know but, it hasn't changed my opinions much.

I: Did Science Club have any other effects on you that we haven't discussed that I might be interested in?

R: Um, it showed me that things are a lot more complicated to actually do than they are to look at. Like the chemistry experiments I did, it was harder than just putting together some basic elements and chemicals, it was more difficult than I'd expected, it just showed me that, um it's a bit harder than I thought to actually achieve something.

I: Right, any other effects?

R: No, none at all.

A.S.I.A. Science Summer School

I: At the end of last year, you attended the A.S.I.A. Science Summer School. Can you tell me something about what you did there, since I wasn't involved?

R: O.K.. At the A.S.I.A. Science Summer School we had lectures on, ah, forensic science, ah, we went to the QUT Optometry Department and they showed us around and told us about various technology that they used in complex eye problems. Um. We were shown, I think, the CSIRO near there or the equivalent of it that was near there, and used just to see what they were doing. That wasn't much interest and, um, we also studied some DNA and some of the electrical science, did some electrical experiments.

I: O.K., Anything else?

R: Um. Not really for me except it changed from what group you were in. Some groups didn't go to the Optometry but went somewhere else. It's fairly large.

I: What effect, if any, did that Science Summer School have on your interest and enjoyment in being involved in science activities?

R: Um, it increased it a lot really, because of the fact that it was just, well, the way they did it was fun and interesting, it showed me a lot of new things and it lent towards the, um, ah, a person going into a science career and it just showed me things I hadn't known before and just various aspects of science.

I: What type of things which

R: Well probably.

I: increased your interest and enjoyment

R: Ah.

I: in being involved in science activities?

R: The DNA was very interesting just to study some of the DNA. We had the DNA of a calf, we just had to, go through and study it, like separate the DNA from the, other material.

I: Right.

R: And the optometry, op, optometry, it was pretty interesting because of all the, um, technology they had and the way in which they showed it to us.

I: O.K. Do you think the Summer school has increased your interest and enjoyment in being involved in science activities a little, medium, or a big bit?

R: Quite a lot.

I: Any other comment on, how it increased, your interest and enjoyment?

R: Um, not really. It just showed me things I hadn't known and let me find something out in a way that made me think I discovered it. They just weren't rattling on and telling me things. It's really interesting.

I: What effect, if any, did the Summer School have on your motivation or desire to continue your study of science later on.

R: Um, it didn't have much of an impact because I, by that stage I was pretty much thinking that I would go on, except, um, the, the developments or the experiments that we did in, um, their chemistry and or the electronics did interest me so it may have aided a little bit in my choosing of the subjects.

I: Right. In what way? Can you, elaborate there.

R: Um, well I can't really. It just sort of motivated me because it was interesting.

I: Motivated you in which area?

R: Probably mainly in the physics chemistry area.

I: Do you think you would have still made the same subject decision choices had you've not gone to the Summer School?

R: I think the subject choices would have been pretty much the same.

I: O.K.. Are there any other effects that that Summer School had on your subject choice decisions?

R: Ah, no, not really.

I: Did the Summer School have any effect on your view of scientists?

R: Ah, well it showed you, we had a police forensic scientist come in and explain his profession and how they went about it and it showed me that some of the um scientists were very normal kind of people without anything at all different about them, um, except it didn't change my view that much.

I: O.K.. Any effects on your view of scientists as people, the type of people they are?

R: No, it just sort of, showed me that scientists are average people except most of our lecturers were fairly old so that sort of put a bit of a myth in my mind that they were old but, basically it didn't change that either.

I: Did you think scientists were basically average people before the summer school?

R: Ah, yes, I had thought that they were except the people that, the lecturers, the assistants showed me that they were quite normal and average, just to confirm what I'd thought before.

I: O.K.. Did the Summer School have any effect on your view of scientists and the work they do?

R: Um, well once again forensic scientists, forensic science was probably the most interesting because it was a branch of science I hadn't really found out about before and it was just, interesting.

I: Hmm hmm.

R: Because it was new and unknown.

I: Did you, change your view as a result of this Summer School?

R: Um.

I: In what way?

R: Yeah, yes it did. Mainly the way it showed me things changed was probably just with the forensic science and dealing with murders or assault or any kind of legal matter and the optometry because it affected me with my glasses and it just showed me that there are very easy ways of doing things with the right technology and great advancements.

I: Ah ha. Did the Summer School have any effect on your view of the role of science in society?

R: Um, it showed me that some of the sciences were very directly involved with society, except I, um, they still seem fairly, any immediate discoveries don't come immediately to the public very soon, they always take a while to actually come to the public and contribute something to social life.

I: O.K.. Did the summer school change, in any other way, your view of the, role of science in society?

R: Um.

I: Or the place of science in our lives?

R: No, not really.

I: Did the Science Summer School have any other effects on you that we haven't discussed yet?

(Change tape)

I: Did the summer school have any other effects on you

R: Um.

I: that we haven't discussed, that you think I might be interested in?

R: Um, yeah, there's the main point of the Science Summer School was that most of it was hands-on which contributes to the enjoyment if you can actually do something while you're learning except other than that nothing really.

Investigation

I: O.K., let's move on now to your individually-designed investigation in Year 9. Can you tell me something about what you did there?

R: Ah, I did a, an experiment to, ah, enable disabled people to open sort of like, um, objects like jars and everything you can really need hands or fingers to use, it's just for disabled. Um. Let's see. It was sort of, I don't think it was much help because of the fact it was always looming over me in Year 9 and there was almost a pain right at the end because it was such a big project and you were so determined to do well that you got nervous and kept doing things wrong in it so, I didn't really like it.

I: O.K.. What effect Alec, did doing that investigation have on your interest and enjoyment in being involved in science activities?

R: Um, I think it almost diminished from it because it was so big, very important, so it was very intimidating if you didn't get it right.

I: What was so big?

R: Well the, um the, way in which it, it seemed such a very big experiment, we had a long time to do it and there were a reasonable amount of marks attached to it so it was reasonably difficult to come up with something.

I: So do you think it had a positive or a negative effect on your interest and enjoyment in being involved in science activities?

R: Probably a negative effect.

I: Little, medium, or big?

R: Very little negative effect, maybe even a neutral effect.

I: O.K.. Any other reasons for that?

R: Um, no, not really, except that it is hard to think of something to study or invent, so that's, that causes difficulty in the interest.

I: O.K.. What effect did that investigation have on your motivation to continue your study of science?

R: Um, it didn't really have an effect it was just a, um, it just sort of was there it was just on the side like. I didn't find it particularly enjoyable cause I hadn't been able to think of anything that I particularly wanted to do. And I think most Year 9's find it a bit ominous just there is, a big assignment there and most of you just can't most of them just can't think what to do. It's too big.

I: It's always the hardest part, isn't it?

R: I mean once you've thought of something, I mean if you can do a good write-up almost anything you can get a good mark after that. Except actually thinking of something which you're happy with, um, is a little bit difficult.

I: O.K.. Any other effects on your motivation

R: No, not really.

I: in science? Did that investigation have any effect on your subject-choice decisions

R: Ah.

I: recently?

R: No, it just, just had no effect really.

I: Did that investigation, have any effect on your view of scientists?

R: No, it had no effect as people or what they did or anything. It was just, that.

I: Did doing that investigation change, in any way, your view of the role of science in society?

R: Um, no it didn't actually it was, was, an assignment so.

I: O.K.. Had no effect on your view of the place of science in our lives?

R: Um, it showed me that scientists, sort of, or inventors contributed things to social life to aid people to make life easier etcetera so it didn't change it much.

I: What do you mean by not change it much?

R: Well, it didn't change my view of the place in society much.

I: Did you already have that view before you did the investigation?

R: Yes, I think so.

I: Did the investigation have any effect?

R: Not really. A little bit but not really.

I: What, positive?

R: Ah.

I: Negative?

R: Probably a small amount of positive effect.

I: Did the investigation have any other effects on you, that we haven't discussed that you think I might be interested in?

R: Um. No not really.

Museum Excursion

I: O.K.. Well finally, then, can you recall the Year 9 excursion?

R: Yeah.

I: It was in two parts and I'd like to consider each part separately.

R: O.K.

I: Do you remember the museum?

R: Yes, I thought it was, it was enjoyable and increased my interest in science, except it was mainly just a learning experience. At the time I didn't really link it with science in any particular way, it was just interesting.

I: You had a fair number of worksheets to do

R: Yeah.

I: at the museum.

R: Um. That was, I think there should have been less worksheets so we could actually take in, um, visually more information, because with the worksheets we had to get them done and that meant running around the whole place trying to find the information.

I: Yes, from what I observed I agree with you there. Do you think that work at the museum that morning had any effect on your interest and enjoyment in being involved in science activities?

R: Um, because, I didn't link it with science I don't think it changed it much, probably not at all, just neutral effect.

I: O.K.. It's interesting that you say that you didn't link it with science, being a science excursion.

R: Yeah, well sort of like, I linked the science centre with science except the museum I linked more with history. And I found that enjoyable because I enjoy history except it was not, the parts that we studied and looked at were not actually well I didn't see them as directly linked to science.

I: O.K.. Did your work in the museum have any effect on your motivation to continue your study of science later on?

R: No, none at all really. Not positive nor negative.

I: Did the work in the museum have any effect on your subject-choice decisions?

R: Ah, no again not at all.

I: Did the work in the museum change your view of scientists in any way?

R: Um, I don't think so.

I: Any effect on your view of scientists as people?

R: Um, no.

I: Or the work they do?

R: Na, nothing really.

I: Did the museum visit affect your view of the role of science in society in any way?

R: Ah, in a minor sort of way but not really.

I: Can you explain?

R: Well the, science developed the camera and, um, knowledge of all the, any biology that was included in there except at the time I didn't link it, it was just, the museum.

I: O.K.. Any other effects of the museum visit on your view of the place of science in society?

R: Um, no not really.

I: Did the museum visit have any other effects on you, that we haven't discussed, that you think I might be interested in?

R: Um, none whatsoever.

Sciencentre *Excursion*

(Been once, about 6 to 9 months prior, with parents.)

I: Finally then, the *Sciencentre* in the afternoon.

R: Hmm hmm. Um.

I: What effect did that activity have, if any, on your interest and enjoyment in being involved in science activities

R: Well

I: in general?

R: it was all hands-on, it was very interesting, you could see or hear the results, and it, it increased a lot my interest in being involved in science, because it was, I could do something and I could try something and then just work out what it was doing and it also informed me of the of various things.

I: Increased your interest and enjoyment a little?

R: A lot.

I: A medium?

R: A lot, a lot.

I: For any other reasons?

R: No, it was just sort of, most of it was new, it was interesting, and it was hands-on.

I: O.K.. Did the work in the *Sciencentre* affect your motivation to continue your study of science in any way?

R: Um, actually I think it did a little, because of the, um, way in which it showed science. It made it more enjoyable and it increased my motivation to continue.

I: Oh, true?

R: So probably a lot.

I: A little, medium, or a lot?

R: A lot.

I: Did the *Sciencentre* visit have any effect on your science subject choices, that you've made recently?

R: Um, maybe a little bit on the physics, because of the sound wave patterns and the sound that was in it, just the wave patterns, um, but other than that not much.

I: You, would you have chosen those subjects

R: I think I still would.

I: without the *Sciencentre* visit?

R: I still would have chosen them except the *Sciencentre* visit made me a bit more sure of my choices.

I: O.K.. Did the *Sciencentre* visit change your view of scientists in any way?

R: Hmm, no I don't think it changed my view of scientists at all really.

I: Either as people or the sort of work they do?

R: No, it all stayed pretty much the same.

I: Did the *Sciencentre* visit have any effect on your view of the, role of science in society?

R: Um, it didn't change it much really, I still thought of science as, um directly linked with what happened in society except not very, quickly sort of like if there was development in science would take time before it actually affected me.

I: Do you think the *Sciencentre* work changed in any way your view of the place of science in our lives?

R: Um, it changed it a little with the fact that it demonstrated some of the sound wave patterns and, ah, air wave patterns and other, and other wave patterns except it didn't change it much.

I: Hmm hmm. Change it in any way at all?

R: Hmm, probably just a little, just a little.

I: Right. In what specific aspect?

R: Well, it changed it a little in the way that it just demonstrated all the different sciences and, what they could be used for, when you thought about them they could then be used in society. So they demonstrated the arch and a number of other things.

I: Did you see principles there that you weren't aware of previously?

R: Um, I wasn't aware of consciously except when I saw them I knew that I, that I, I had always assumed that they would happen except it showed me in a three-dimensional physical way that they did, just like, things from there I knew from for fact, on paper, except they actually showed it happening.

I: Would it be fair to say that the experience at the *Sciencentre* broadened your view of the role of science in society?

R: Yes, that, it would be fair to say that it did broaden my view of science in soc in society.

I: In what way?

R: Um, well, it was just more directly linked than I had originally thought, except I.

I: What do you mean by it?

R: Well.

I: Science?

R: Science is more directly linked to society than I had originally thought except that it was still a bit gone from society. Like any developments will take time.

I: O.K. Did the *Sciencentre* visit have any other effects on you that we haven't discussed.

R: Ah.

I: That you think I might be interested in?

R: It was very enjoyable and, helped in my understanding of stuff, the more difficult or at least there were difficult aspects then except not much, nothing else really that we haven't already mentioned.

I: O.K.. Finally, now, in our preliminary discussion, Alec, you mentioned the fact that the Year 7 Australian Schools Science Competition, in which you got an Honours Certificate

R: Hmm.

I: has some special lasting memories. Can you tell me something about that?

R: Well, the reason it had a definite lasting memory was because I went extremely well throughout the State.

I: Right.

R: Haven't gone as well since then, except it still stuck in my mind because I had gone well.

I: Do you think that competition had any effect on your interest and enjoyment in being involved in science activities?

R: Ah, a little because I went so well, it motivated me a little but again not much.

I: A little, medium, or a lot?

R: A little.

I: That's your motivation?

R: Yeah.

I: In what?

R: In any areas of science.

I: O.K.. What about your interest and enjoyment in being involved in science activities? Did it change that in any way?

R: Um, maybe a little.

I: Positive or negative?

R: Ah, a little positively.

I: Right.

R: But not much, mainly in the general sort of fashion.

I: Did it have any effect on your view of scientists?

R: Oh, no, from what I can remember it was a fairly basic sort of test, and it just had thinking processes in it, it had to do with science except it wasn't that much that changed my view of scientists as people or what they do or there, or science's role in society. It was a very, it was a more of a thinking skills test, I feel.

I: Didn't have any effect on your view of the role of science in society?

R: No, not at all.

I: O.K.. Did it have any long-term lasting effects that were linked with your subject choices, your recent subject choices?

R: No, no real long-term lasting effect.

Appendix 3.I

Sample Interview Log: Zita, Year 9

Zita November 15, 1993 7.00 p.m.

Drawing Room, girls boarding campus Tapes 15 & 16

Tape position

Tape 15

262 *Senior science subjects*

Wants to be a registered nurse. ∴ need some biology.

Tertiary/career thoughts

As above.

285 *Interest and enjoyment in science*

Increased (medium bit).

Reasons: Done more things this year (e.g. although went on trip last year, Sciencentre visit has had an effect (discuss in detail later). Done more experiments this year than last year. "I'd rather . . . find out for myself something rather than having the teacher just stand up there and tell us."

223 *Motivation to continue science*

Increased (a little).

Only decided to become a registered nurse this year, & so she knows she has to study science to do it & this has motivated her a little.

240 *View of scientists*

Still agrees with last year's views. Has nothing to add.

269 *Role of science in society*

Last year's views still hold. Nothing to add.

302 *Aust. Schools Science Comp.*

(a) No effect. (b) No effect.

Senior subjects/career thoughts: No effect.

(c) No effect. (d) No effect.

General: No effects. "It was just something I did." Should offer to next year's group because it's "a good opportunity to show your knowledge."

Tape 16

Investigation

Guinea pigs, feeding them different kinds of food, looking at effects on their weight and behaviour (observation). (Never done this type of activity before, although there was a science demonstration as one choice in a primary school learning experience.)

7 (a) Increased (a little bit).

Because it was something different to do and a new experience. Different to class experiments because no set procedure to follow.

(b) No effects.

Senior subjects/tertiary/career: No effect.

16 (c) Investigation made her "realise that their work wasn't just all hard work, that sometimes they might do have fun while they're still doing their work, experimenting." Had an idea about this before investigation, but wasn't sure.

(d) No effect.

General: Should offer to next year's group, because gives you a chance to do what you want to do and find out by yourself. This is good because tasks are not teacher-imposed.

Mine Excursion

Never done similar before.

46 (a) No effect.

Good to see different processes at mine, how coal gets to other places, where it comes from in the first place.

(b) No effect.

Senior subjects/career thoughts: No effect.

(c) No effect.

(d) No effect.

General: It was interesting, but not a high priority for next year's group (i.e. could replace it with something else).

73 *Sciencentre Excursion*

Had been once before (primary school), but new building now.

(a) Increased (medium/a lot)

Because there were a lot of new things there and they were different (from previous visit). "I'd rather see things and do things like I said before." A lot of things had been advanced, more things to see and do, exhibits more popular.

(b) No effect.

Senior subjects/career thoughts: No effect.

104 (c) "Some of the things there, um you'd sorta have to be pretty brainy to work out how, to work those sorts of things." ∴ trip made her think that scientists were brainy people.

(d) No effect.

General: More time might make it more interesting (there's a lot to see). Should take next year's group; a worthwhile trip.

130 *Look at previous year's activities*

Remembers these activities, but none are having any effect in areas (a) or (b). Good to see students work in Science Comp..

Appendix 3.J

Focus of the Interview: Round 2

1 (Year 11 only) Thoughts about a career or a tertiary course? Any changes since last interview?

(Year 9 only) Thoughts about senior science subjects or a career?

2 How and why have your perception in the following areas changed since last interview?

(a) Your interest and enjoyment in being involved in science activities.

(b) Your motivation to continue your study of science.

(c) Your view of scientists.

(d) Your view of the role of science in society.

3 The effects of special science activities in the areas (a) to (d) listed above.

Appendix 3.K

Feelings About the Interviews

1 How honest/accurate were your responses?

2 How comfortable did you feel:

(a) in general?

(b) about being honest?

3 How complete were your comments?

(i.e. were there things you could have said but decided not to? If so, why?)

4 Any other comments about the interviews (positive or negative)?

Appendix 7.A

Text of Response to a Queensland School Geology Competition

October 18, 1993

The Competition Convenor
Queensland School Geology Competition
Geological Society of Australia Incorporated
Queensland Division
GPO Box 1820
BRISBANE QLD 4001

Dear Sir/Madam

I write to express a concern (shared by a colleague) about the structure of this year's Senior Paper (I have not seen the Junior Paper). I suggest that too many questions have a content (social knowledge) base which is not necessarily covered by our Junior Science Syllabus core (see enclosed) and that this:

1. is contrary to the flyer promoting the competition which states that "questions are mainly process (reasoning) type rather than content questions, and are intended for all students",

2. is inappropriate as students are not equipped with the tools needed to deliberate effectively on the question, and

3. will result in a negative effect on students in the affective domain; contrary to the aim of the competition.

Questions 7, 8, 10, 11, 12, 13, 15, 16, 17-20, 22, 23, 25, 27-29, 31-36, 42, and 44-47 (over half the paper) appear to fall into this category. Other content questions may or may not be covered by a school, depending upon their interpretation of the syllabus (but no guarantees exist) or might be best able to be "answered" by elimination alone (i.e. Questions 1, 2, 40, 43, 47, and 49). At the same time, however, many of the other questions appear to be excellent process questions.

The relatively low certificate category cut-offs (e.g. 39% for a Credit) suggests that students State-wide struggled with the items. I am currently engaged in qualitative research examining the effects on student affect of activities like the geology competition and it is becoming apparent that:

1. particular events such as competitions like yours can make a significant impact on students' interest in science activities, their motivation to continue their study of science, their view of scientists, and their view of the role of science in society, and

2. few things are more motivating than success. While artificially high scores for all students can lead to a misleading perception of ability, low scores resulting from the use of inappropriate questions will undoubtedly alienate students.

The need is, in my opinion, for more such process type questions which, by testing what a student can do as opposed to what they don't know, will more likely increase students' interest in, and motivation to continue, the study of geology and broaden students' perceptions of career opportunities in the earth sciences and the role of geology in society. Please accept this brief note in the constructive manner in which it is intended. I have observed that questions on the Australian Schools Science Competition papers (sample question booklets enclosed), for example, have gone through an evolutionary period similar to what I am suggesting desirable for your competition questions. Some ten years ago some thought they were also too heavily content based.

I trust that this brief contribution may assist in some way in the evaluation of this years Senior Paper and the production of future papers which are likely to contribute more positively to the affect of students.

Yours faithfully

Peter Eastwell
Head of Science

Appendix 8.A

A Summary of the Effects of Competitions on Students

Activity	Year offered	Dependent variable		
		Interest, enjoyment, and motivation	Perceptions about scientists	Role of science in society
Australian Schools Science Competition	8-12	Overall positive effect, most often as a result of receiving an award, but usually in conjunction with first sitting only	First-sitting-only effect of broadening some students' (mainly boys) perceptions about the type of work in which a scientist can engage	First-sitting-only effect of broadening some students' perceptions about, and increasing their view of the importance of, the role of science in society
National Chemistry Quiz	10-12	As for Australian Schools Science Competition	No effects	As for Australian Schools Science Competition, but far less widespread
Queensland School Geology Competition	11	Difficulty of questions led to overall decline in motivation towards geology	No effects	No effects
Biology Olympiads	11	No effects	No effects	Some content had a positive effect

Appendix 8.B

A Summary of the Effects of Excursions on Students

Activity	Year Offered	Dependent variable		
		Interest, enjoyment, and motivation	Perceptions about scientists	Role of science in society
Science Contest Excursion	8	Positive effect on the interest and enjoyment of most students and on the motivation of some students, most often because it was interesting and/or enjoyable	Broadened perceptions of some students about the type of work in which scientists engage	Broadened some students' perceptions about the contribution of science in society
Planetarium Excursion	8	As for Science Contest Excursion	As for Science Contest Excursion	As for Science Contest Excursion
Sciencentre Excursion	9	As for Science Contest Excursion	As for Science Contest Excursion for 1 junior student, plus showed work of scientists can be interesting and scientists must be "brainy" in case of 1 junior student each	Effect as for Science Contest Excursion but on 1 junior student only
Mine Excursion	9	Positive effect on some students	As for Science Contest Excursion	As for Science Contest Excursion

Appendix 8.B (cont'd)

Activity	Year Offered	Dependent variable		
		Interest, enjoyment, and motivation	Perceptions about scientists	Role of science in society
USQ Seminar	9	Positive effect on 2 of the boy volunteers because it was interesting	As for Science Contest Excursion but on 1 student only	Effect as for Science Contest Excursion but on 1 student only
Vacation Science Tour	8-11	Positive effect on the interest and enjoyment and/or motivation of most volunteers because they were interesting and broadened view of future opportunities in science	Negated stereotypical image of some students	Increased and/or broadened or reinforced perception of most students
A.S.I.A. School	10	Positive effect on both the interest and enjoyment and the motivation of all volunteers, mainly because it was interesting, fun, and enjoyable	Negated stereotypical image or reinforced normality for all students	As for Vacation Science Tour
R.A.C.I. Lecture	11	Positive effect on the interest and enjoyment and/or the motivation of most students, mainly because it was interesting	Reinforced normality for some students, but reinforced stereotype for 1 student	As for Vacation Science Tour
CSIROSEC Excursion	12	Positive effect on motivation of 1 student only because it was interesting	Reinforced normality for 1 student only	No effects
Youth Physics Lecture	12	No effects	No effects	No effects

Appendix 8.C

A Summary of the Effects of Practical Work Activities on Students

Activity	Year offered	Dependent variables		
		Interest, enjoyment, and motivation	Perceptions about Scientists	Role of science in society
Evening Science	8-12	Positive effects in both areas for most students; a small negative effect on 1 student's motivation only	Broadened perception of some students about the nature and variety of the work of scientists	Broadened perception of some students about the role of science in society
Science Club	8-12	No effects	No effects	No effects
Investigation	9	Increased both the interest and enjoyment and the motivation of many students, often because it was enjoyable, and a negative effect in both areas for 2 of the 15 students	As for Evening Science	As for Evening Science, often increasing view of importance as well
Primary Interface	10	Increased interest and enjoyment of most participants, and motivation of some, mainly because it was enjoyable and fun but also, for 2 students, seeing the primary students enjoy it or learning from it	As for Evening Science	As for Evening Science

Appendix 8.C (cont'd)

Activity	Year offered	Dependent variables		
		Interest, enjoyment, and motivation	Perceptions about Scientists	Roles of science in society
Work Experience	11,12	Increase in interest and enjoyment of some students, increase in motivation of nearly all students, and decrease in motivation (in a specific area only) of 1 student	Negated stereotypic image of 2 girls	Increased view of most participants because it broadened their view
Senior science investigations				
Biology	12	Increase in interest and enjoyment of 1 student only in 7	No effects	No effects
Chemistry	12	Increase in interest and enjoyment of many students and motivation of some students	No effects	No effects
Physics	12	Decrease in interest and enjoyment of 1 of 7 students	No effects	No effects