Transition or lack of it? Looking at the changes in students' attitudes to, and interest in, science over the primary/secondary interface

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Transition or Lack of it? Looking at the Changes in Students’ Attitudes to, and Interest in, Science over the Primary/Secondary Interface

A thesis submitted in fulfilment of the requirements for the Degree of Doctor of Philosophy at Southern Cross University by Marianne Ruth Logan BA, Grad Dip Ed,

SCHOOL OF EDUCATION
SOUTHERN CROSS UNIVERSITY

March 2008
THESIS DECLARATION

I certify that the work presented in this thesis is, to the best of my knowledge and belief, original, except as acknowledged in the text, and that the material has not been submitted, either in whole or in part, for a degree at this or any other university.

I acknowledge that I have read and understood the University's rules, requirements, procedures and policy relating to my higher degree research award and to my thesis. **I certify that I have complied** with the rules, requirements, procedures and policy of the University (as they may be from time to time).

Marianne Logan

Signature of Candidate: ____________________________
ABSTRACT

The science education literature reveals a crisis in school science in Australia, and a number of other countries (Tytler, 2007a), relating to a decrease in positive attitude in science as students move from primary school into secondary school (Braund & Driver, 2005; Ferguson & Fraser, 1998; James & Smith 1985; Jarman, 1990; Keogh & Naylor, 2004; Simpson & Oliver, 1985) and as students progress through secondary school (Baird, Gunstone, Penna, Fensham, & White, 1990; Simpson & Oliver, 1990; Yager & Yager, 1985) as well as declining numbers of students choosing science subjects in senior secondary school (Goodrum et al., 2001) and pursuing science as a career (Metherell, 2006; Rothapfel, 2004). This is at a time when science and technology play a major role in society and people are looking towards science to address the environmental problems associated with global warming and health issues in the 21st Century.

The studies described in this thesis look at the changes in students' attitude to, and interest in, science, and the factors that affect these changes over the primary/secondary interface. The major research projects outlined in this thesis are a longitudinal case study and a cross-sectional attitudinal survey.

The case study looks at 20 students who were in year six in 2004, and year seven in 2005. It is essentially a qualitative component and the main focus of this research project. In order to give students a voice and to see how students perceive science, multiple sources of data were used in this case study. These included: semi-structured interviews; focus groups; classroom observations; short surveys; attitudinal questionnaires; teacher interviews; students' journals; students' work samples; parent surveys; and researcher diaries. The attitudinal survey is a quantitative component consisting of an attitudinal questionnaire (developed by Pell and Jarvis [2001]) that was administered to students in years 5 to 10 ($N=264$) in 2004, in the schools and classes where the case study participants attended. The findings from this attitudinal survey therefore provided contextual data for
the case study and a benchmark to allow comparison of the 20 study participants with this larger sample.

In contrast to the results of the attitudinal survey, which followed the common trend of decline in science interest as students go from primary into secondary school, the majority of the participant students retained a positive attitude to, and a genuine interest in, science, over the primary/secondary interface. The results of data gained from both the quantitative and qualitative components of the study, including the commonalities and differences arising from narratives that were developed for each participant student over the primary/secondary interface, are presented.

The final chapter of this thesis outlines a project initiated by the teachers in the participant schools involved in the studies in response to being presented with the findings of the attitudinal survey which revealed a decline in students’ positive attitudes towards science over the primary/secondary divide. The project was initiated to enhance innovative teaching in science and it included a bridging unit of work that was designed in the attempt to create a smooth transition for students as they moved from primary into secondary school in science. Although the studies outlined in this thesis are small and cannot be generalised, important issues have emerged that have implications for science educators.
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I wish to firstly thank my supervisor Associate Professor Keith Skamp for his exceptional help, support and encouragement throughout my doctoral studies. Keith has given me exceptional guidance and assistance and I am overwhelmed by his great patience and tolerance. His faith in my abilities has been an inspiration resulting in my confidence to proceed with this process.

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To the study student participants, their teachers and parents, I want to extend my sincere gratitude for their willingness to participate and for their assistance during this project. I would like to thank the teachers involved in the project discussed in the final chapter of this thesis and their desire to address issues associated with the findings of the research. I also wish to thank the administrative and other teaching staff, at the schools where the study was undertaken for their willingness to help with the project.

To my late father, Frank Swain who was so proud when I submitted this thesis in November 2007, but sadly passed away in January 2008, I want to thank him sincerely for his love and guidance throughout my life. To my mother Rhoda Swain, and my sister Paula Bowles, who have given me much encouragement and support throughout this process, I am grateful. I would like to thank my brother John Swain for his support. To my son, Dane Logan, I want to thank him for his humour, tolerance, support and words of encouragement. Finally I want to thank my husband, Alan Logan to whom I am deeply grateful for his love, support, tolerance, encouragement, caring and preparation of meals while I have been so focussed on completing this doctoral thesis.
PREFACE

The following publications and conference papers are related to this thesis:

**Methodology, Reported in Chapter Three**


**Attitudinal Survey, Reported in Chapters Four, Six and Eight**


**Case Study, reported in Chapters Five, Seven and Eight**


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CHAPTER ONE

INTRODUCTION

The Research Context and Significance

*Decline in Positive Attitudes to Science over the Transition (or lack of transition?): A matter of Concern*

The time of transition from primary into secondary school is quite an adjustment for many children particularly as they start specialist classes for a range of subjects (Ferguson & Fraser, 1998). In fact this time, known as ‘transition’, could be described as a lack of transition since the students often experience a sudden, abrupt change during this period. This ‘trauma of transfer’ may be transient (Jarman, 1990, p.19) but there may be lasting negative consequences in the adjustment of many students to secondary science where the changes in pedagogy and curriculum are quite considerable (Braund & Hames, 2005). The findings of studies that have been conducted during this phase (Braund & Driver, 2005; Ferguson & Fraser, 1998; James & Smith, 1985; Jarman, 1990; Keogh & Naylor, 2004; Simpson & Oliver, 1985) have revealed that there was a considerable decrease in positive attitudes towards science of students from year six (primary school) to year seven (secondary school).

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1 The author believes that the term “transition” indicates a gradual, smooth, adjustment to secondary school in contrast to the abrupt change that is experienced by many students during this period particularly with school science. Hence the term “transition” (which is typically used when students progress from primary into secondary school) has been replaced with the term “primary/secondary interface” or in some instances “moving from year six primary school into year seven secondary school”.
Decline in Positive Attitudes to Science as Students Progress through Secondary School

Research studies from a number of countries have shown that positive attitudes towards science decline over the secondary schooling years (Baird, Gunstone, Penna, Fensham, & White, 1990; Simpson & Oliver, 1990; Yager & Yager, 1985). This trend was reflected in the findings of a national study undertaken by Goodrum, Hackling and Rennie (2001) that investigated science teaching and learning in Australian schools. It was evident from this national study that there was a decline in the number of students choosing science subjects in senior secondary school.

An Australian Federal Government audit in 2006, revealed that there was a shortage of scientists in Australia (Metherell, 2006). It is recognized that there is a correlation between positive attitudes towards science and choosing science related subjects in upper secondary school (Lindahl, 2003; Simon, 2000). This decrease in the positive attitudes of students towards science as they progress through school and the decline in numbers of students choosing science subjects in senior secondary school leading to a reduction of numbers of students pursuing careers in science, are matters of concern. Although there has been a large amount of research into students’ attitudes to science over the past few decades, a number of gaps in this area of research have been identified in the science education literature. These gaps include: attitudinal studies have become significantly less common since the “peak of interest and activity in the 1970’s” (Ramsden, 1998, p. 125); few qualitative studies have been undertaken to look at students’ attitudes towards science (Osborne, Simon & Collins, 2003); more sensitive, complex studies (Jenkins & Pell, 2006) revealing the relationship between attitude, motivation and cognition would be valuable (Koballa & Glynn, 2007); longitudinal studies in attitude research are important (Jenkins & Pell, 2006) and not common (particularly qualitative) (Reiss, 2000); and more studies are required, to identify factors surrounding the decline in positive attitudes towards science (Lindahl, 2003), and to listen to the voices of students regarding effective teaching in the subject (Jenkins & Pell, 2006; Osborne, et al., 2003) (these gaps are outlined further in Chapter 2).
In Australia and other post-industrialised countries students are avoiding science uptake in senior schools and careers in science at a time when we need more than ever “science and technology-based professionals to carry the nation into a technologically driven future” (Tytler, 2007a, p. 1) and to address the enormous environmental problems facing us in the 21st Century. Research studies in the area of science attitude and interest, are required to influence the reform in pedagogy or curricula which so urgently needs to take place if we are going to overcome this crisis in science education. Therefore a longitudinal study looking at students’ attitudes towards, and interest in, science as they move from primary into secondary school where there is often a marked decline in positive attitudes towards science, looking for reasons behind this attitudinal decline, and seeking the views of students as to experiences in science that lead to motivation towards, and engagement in science, are highly significant areas of research.

**Purpose of the Study**

The purpose of this study was to look at the changes in students’ attitudes to, and interest in, science, over the primary/secondary interface. The study was designed to gain a deep understanding of students’ attitudes to both school science and science generally and the factors that impact on these attitudes. The main component of the study was a longitudinal ‘case study’, which involved 21 student participants in year six, in 2004 and 20 students in year seven, in 2005. In order to see science from the students’ perspective and to give the students a voice, multiple methods of data collection were undertaken including, student and teacher individual interviews, peer focus groups, classroom observations, student and parent surveys, and observation of students’ work samples and journals. As this case study involved a relatively small number of students, a second component was undertaken; an attitudinal survey, involving 264 students from years five to ten. This attitudinal survey was administered in the schools and classes from where the case study participants were selected, to gain a more encompassing picture of students’ attitudes across the year levels. If students’ attitudes to school science are to remain positive over their schooling years, it is important that their school science experiences capture and maintain their interest and encourage motivation towards, and engagement in, their science lessons. This research study is on a small scale and cannot be generalised but it identifies and highlights aspects of science, pedagogical practices and classroom
environments that interest students and enhance positive attitudes towards the subject. It also identifies aspects that have a negative effect on students’ attitude to, and interest in the subject. The combination of qualitative and quantitative research methods provided cross validation of data supporting the students’ voices which were loud and clear in this study, regarding their school science and what ‘turns them on to’ science or what leads to disinterest and frustration in the subject. Many of the issues arising from this study support those in the research literature so it is essential for science educators to address these issues in order to maintain the students’ positive attitudes towards science in primary school, over the primary/ secondary interface, and throughout their secondary schooling.

The Research Questions

Two research questions were addressed in the studies outlined in this thesis:

1. How do children’s attitudes to, and interest in, science change over the primary/secondary interface?
2. What are the factors that affect the changes in attitude and interest towards science?

Outline of the Thesis

The researchers’ background is often included in the introduction of thesis documents. However as this account is an integral part of the literature review and as it outlines the personal journey of the researcher and reveals how literature influenced, informed and guided this study, it has been included in the literature review (Chapter 2). In a sense the beginning of Chapter two is a continuation of the introduction.

The research design and methods (Chapter 3) outlines the methodology underpinning this study and gives a detailed account of the selection procedures and data collection methods used for both the attitudinal survey and the case study; the methods of analysis, and their credibility, trustworthiness, transferability, limitations, and strengths are outlined.

Although the attitudinal survey was essentially one of the methods used to inform the case study, these studies were conducted and analysed as separate research projects.
The results of the attitudinal survey are presented in Chapter 4 and the results of the case study are presented in Chapter 5. The discussion and implications for teaching, for both components of the study are also separated into two chapters, Chapter 6 (attitudinal survey) and Chapter 7 (case study).

Chapter 8 provides an overview of what has been achieved in this thesis, where the similarities and differences between the two studies are discussed, together with the limitations of the study and recommendations for further research.

As a result of presenting the findings of the attitudinal survey reviewed in this thesis to the teachers in the primary and secondary participant schools, a number of teachers initiated a project to address issues that emerged from the results of the study and invited the researcher (Author of this thesis) to take part in the project in the role of Teacher Associate. It was decided to include a discussion of this project as a final chapter (Chapter 9) to this thesis to demonstrate how research can influence teachers to take action. It outlines the innovative initiatives implemented, implications for educators but also highlights the problems that emerged and the difficulties associated with the implementation of strategies to address this important issue of students’ negative attitudes towards science.
CHAPTER TWO

LITERATURE REVIEW

Introduction

The purpose of this literature review is to outline the personal journey of the researcher and show how the literature has influenced the overall direction this study has taken. The use of first person in this chapter is intended to introduce the reader to how the research originated from a personal perspective. This Literature review is divided into six main sections; these are:

1. background to my research;
2. scientific literacy and science curricula;
3. an overview of the constructs, attitude, interest and motivation, how these constructs interrelate and relate to student engagement, and the overlap and confusion between the constructs;
4. the decline in positive attitude to, and interest in, science and the impact of this decline;
5. variables contributing to a decline in positive attitude to, and interest in, science; and
6. other factors relating to research in this field.

1. Background to my Research

What Initiated My Research?

As a school student, science was one of my least favourite subjects. However after studying science as a mature adult at university, I became aware of just how interesting the subject can be. My goal as a secondary science teacher was to create science lessons that stimulated a positive attitude towards the subject. Science can be presented with a creative and innovative approach, which may foster an interest in the subject. A common aim of school science educators is to promote enthusiasm for the subject (Simon, 2000, p. 104). However, after teaching for a number of years, I became aware that many students, although displaying temporary interest in the science activities, developed a negative
attitude towards the subject as they progressed through school. Woolcott (1992) described how research could be “problem-focussed” or “problem-orientated” (p. 7). The problem of students developing negative attitudes towards science as they progress through school and identifying factors which influence students’ attitude to, and interest in, science was the focus of this research project.

Disenchantment with Science

Early in my study I read a report by Goodrum, Hackling and Rennie (2001) into the Status and Quality of Teaching and Learning of Science in Australian Schools. Goodrum et al. (2001, p.viii) described the picture that evolved from their National study, as being “disappointing” and they stated how students are “disenchanted with science”. They suggested that the declining number of students choosing science related subjects in senior secondary school reflected this “disenchantment” (p.viii). This trend of students failing to choose science in senior secondary school is not confined to Australia and is a cause for concern in other countries (e.g., Lindahl, 2003; Osborne, Simon & Collins, 2003).

2. Scientific Literacy and Science Curricula

Economists agree that science is essential to maintain a “contemporary, innovative and successful economy” (Rothaphfel, 2004, p.24). Scientific literacy and the ability of citizens to fully understand science, enables economic progress or according to Rothaphfel (2004, p.24) “scientific literacy is perhaps the driving force of an economy”. The importance of the public having a broad understanding of major scientific ideas and how science has contributed to our way of life was discussed by Millar and Osborne (1998). It is recognized that the goal of science education generally is to develop scientific literacy in the population (Feasey, 2004; Gerber, 2001). Bybee and DeBoer (1995) stressed that achieving scientific literacy should be the purpose of “all students” not just those students who plan to follow a career in science and engineering (p. 384).

To achieve 'scientific literacy', students require a sound understanding of the subject. At present I am employed as a casual university lecturer, in curriculum studies in primary science and technology. Although I have not undertaken formal research in this area, I have observed many students entering university, after graduating in secondary school,
appearing to have limited knowledge of school science. In a study involving pre-service primary teachers, Murphy, Beggs, Hickey, O’Meara and Sweeney (2001) revealed that many of the participants, including those who had completed five years of secondary science, found some areas of the primary science curriculum difficult to understand. It was suggested by Feasey (2004) that the general population has limited understanding, and often a negative view of science. The public often see scientists as being elitist and science as being associated with the problems of the world (Feasey, 2004). The viewpoint of young people, according to Purchon (as cited in Feasey, 2004) was that science is destructive and associated with issues such as: global warming; pollution; the technology associated with wars; and experimentation with animals. Feasey believed the public’s perception of science, is contradictory. She discussed the popularity and intrigue of television science programs alongside the negative perception of science and scientists. The ability to understand science and technology “as an integral part of our society” was highlighted by Bybee and De Boer (1995, p.384).

A belief that scientific literacy is a “high priority for all citizens” is fundamental in the teaching of science and it is important to clearly define what is meant by scientific literacy (Goodrum et al., 2001, p.vii). The essence of how the National Science Council (NSC) (1996) in the United States described scientific literacy was summarised by Goodrum et al. (2001) in the following three points:

1. a scientifically literate person has “the capacity to engage in the discourses of science and the ability to evaluate scientific evidence and arguments” (p. 12);
2. not all people will “exhibit scientific literacy” in the same way, as each person is an individual and has differing “strengths and interests” (p. 12); and
3. scientific literacy is something that “develops and deepens“ throughout a person’s life (p.12).

The NSC stated that the attitudes and values children establish towards science in the early years will “shape a person’s development of scientific literacy as an adult” (as cited in Goodrum et al. p. 12).

Goodrum et al. (2001) consequently defined scientific literacy as:

the capacity for persons to be interested in and understand the world around them, to engage in the discourses of and about science, to be sceptical and questioning of
the claims made by others about scientific matters, to be able to identify questions and draw evidence-based conclusions, and to make informed decisions about the environment, and their own health and well being (p.15).

Another definition of scientific literacy, according to the Organisation for Economic Co-Operation and Development (OECD) in the Programme for International Assessment (PISA), is:

Scientific literacy is the capacity to use scientific knowledge, to identify questions and to draw evidence-based conclusions in order to understand and help make decisions about the natural world and the changes made to it through human activity.

Three competencies appeared to be central to the majority of definitions when the literature was reviewed on scientific literacy and these competencies were developed for use in the OECD-PISA (2003) test cycles (Olsen, 2004); these are outlined in the following:

1. understanding scientific investigation;
2. interpreting scientific evidence and conclusions; and

The Australian Chief Scientist, Jim Peacock, who recognized the enormous changes in science over the past few decades, highlighted the relevance of scientific literacy in the following statement:

Science is a constantly evolving field. Thus, much of the content knowledge I learned in school and university was not directly used in my career as a plant scientist. I learned to approach individual experts in a field, tracking information in how to tackle an unknown. Every day we are faced with unfamiliar tasks and required to make decisions in unfamiliar contexts. Students will become more effective citizens by being able to locate, analyse and critique information to form their own opinions rather than being able to provide the atomic number of an element such as lead (Peacock, 2007, p. iii).

From personal observation as a secondary teacher, finding time to present the large amount of content covered in the science syllabus is a problem in schools. It was interesting to read that curricula in the United States and other countries have been
criticised for being “content heavy” and have left little time for students to reflect and build on their scientific understanding and cope with science in their lives (Goodrum et al., 2001, pp.7-8). Millar and Osborne (1998), looking at the curriculum in England and Wales, observed that:

the current curriculum retains its past, mid-twentieth-century emphasis, presenting science as a body of knowledge which is value-free, objective and detached – a succession of facts to be learnt, with insufficient indication of any overarching coherence and lack of contextual relevance to the future needs of young people (p.3).

The science curriculum generally has traditionally been based on recruiting the scientific elite and a focus on “canonical science as mental training” and this has lead to the subject being successful in maintaining its high status in the past (Tytler, 2007a, p. 17). However, now with the great changes that are taking place in our society, it is important to convince many teachers, parents and the wider community that it is time for a change to the traditional curriculum. Tytler argued that this very same science curriculum that is essentially designed to train high ability students for a career in science appears to be turning students away from science. In a study looking at Australian scientists’ views of the school science curriculum, it was found that these scientists generally believed that the school curriculum was out of date and was geared at the training of future scientists. These scientists agreed science would be much more relevant to students if it was engaging, reflected “the way science operates in the community”, and provided opportunities for all students to become scientifically literate, not just students who want to pursue a career in the subject (Tytler & Symington, 2007, p.13). School science has not kept up with “changes in science and society” (Tytler, 2007a, p. 3); therefore it clearly evident that it is time to change this outdated philosophy behind school science and create relevant science programmes that are designed to engage all students.

When looking at the views of 70 teachers in England and Wales, Leach (2002) found that like the Australian curriculum, teachers generally believed that their curriculum is designed to prepare students for future studies in science rather than preparing them for life in a society where science and technology play such a major role. The issue of a ‘content heavy’ curriculum was summed up in a comment by a teacher in Leach’s study, “there is no time to discuss issues with the kids” (p. 47). English students recommended, in a review of their science curriculum, that fewer topics be covered in order for the information to be
presented with greater depth and with “more detailed explanations” (Murray & Reiss, 2005, p. 91).

The results of an international study of 14-year-old students by Martin, Mullis, Gonzalez, Gregory, Smith, Chrostowski, Garden and O’Connor (2000) (Trends in International Mathematics and Science Study, TIMSS 1999) revealed that students from Australia were amongst the least positive in their attitude to science along with Japan, Korea, Chinese Taipei and Hong Kong. Martin et al. discussed how these countries where the students’ attitudes are least positive, are also countries with high average achievement in science. The science curriculum is demanding in these countries and the students obtain above average results; nevertheless the students lack enthusiasm for science (Martin et al.). However, Martin et al. were careful to mention that there was a relationship between positive attitudes and high achievement overall in science in many other countries.

Attitudinal research is essential in assisting the development of curricula that enhances scientific literacy (Simpson, Koballa, Oliver & Crawley, 1995). Simpson et al. believed that in the United States “unless policy makers are willing to set standards and monitor performance on attitudinal as well as achievement outcomes, students are unlikely to attain the level of scientific literacy necessary to become a functional member of society” (p. 232).

This study occurred in New South Wales (NSW), Australia. The aim of the NSW Science and Technology K-6 Syllabus (Board of Studies [BOS], 1991) was to, “develop in students competence, confidence and responsibility in their interactions with science and technology leading to:
  
• an enriched view of themselves, society, the environment and the future; and
• an enthusiasm for further learning of science and technology” (p.7). The reality is that in many Australian primary classrooms “little or no science is taught” (Goodrum et al., 2001, p. 87). However Goodrum et al. suggested that where science is taught in primary school it is often student-centred (as opposed to teacher-directed), where students are encouraged to investigate and explore, and the subject is popular with the students.
The NSW Board of Studies, *Years 7-10 Science Syllabus* (BOS, 2003) stated in its rationale:

The study of science provides opportunities for students to develop the skills of working scientifically by engaging them in thinking critically and creatively in problem-solving processes. Students work individually and in teams in planning and conducting investigations. They are encouraged to critically analyse data and information, evaluate issues and problems, develop questions for enquiry and investigation, and draw evidence-based conclusions. Students are called on to apply and communicate their findings, understanding and viewpoints in a scientifically literate way when making decisions about the environment, the natural and technological world.

By engaging students in a range of learning experiences that build on prior learning and are set in meaningful and relevant contexts, they are led to a more scientific understanding of their world and the way that scientists work. It is through this enquiry and investigation that students develop a deeper appreciation of scientific endeavour, of science as an evolving body of knowledge, of the provisional nature of scientific explanations and of the complex relationship between evidence and ideas (p. 8).

This rationale would suggest that the intended curriculum for school science in NSW (across grades Kindergarten-10) would encourage science that is relevant to students, be engaging, encourage critical thinking, creativity and promotes scientific literacy. However, Goodrum et al. (2001) found that the implemented curriculum in Australia generally resulted in students often being “disappointed” when they enter secondary school as they experienced science that was not engaging or relevant to their lives and offered little “challenge or excitement” (p. viii). Goodrum et al. quoted a teacher from a focus group in their study, who said, “secondary schools put out the fire of desire that is lit in primary schools” (p. 87). According to Simpson and Oliver (1985) it is during this ‘critical period’ of middle school years that students develop “their most lasting impressions of science” (p. 511).
If students’ enthusiasm for science is waning in early secondary school, how can students be expected to maintain their interest in order to gain a sound understanding of the subject and become scientifically literate? Pondering this question led to a personal decision to undertake research relating to students’ attitudes to, and interest in, science. Before commencing research in the area of ‘attitudes’ and ‘interest’ it was essential to gain a clear understanding of these constructs.

3. An overview of the Constructs, Attitude, Interest and Motivation, how these Constructs Interrelate and Relate to Student Engagement and the Overlap and Confusion Between the Constructs

This section of the literature review is divided into the following relevant subsections:

a. attitudes, interest, and motivation;
b. student engagement;
c. overlap and confusion between attitude, interest, motivation, and engagement; and
d. linking and contrasting attitude, interest, motivation, and student engagement.

(a) Attitudes, Interest, and Motivation

Simpson, et al. (1995, p. 211) suggested that the field of science brings together “learners, science and society” and this allowed growth to occur in the “three educational domains: cognitive, psychomotor and affective”. Simpson et al. outlined these three domains:

1. the cognitive domain involves the acquisition of facts and concepts along with the development of problem-solving and reasoning skills;
2. the psychomotor domain involves the development of physical and dexterity skills; and
3. the affective domain includes a host of constructs, such as attitudes, values, beliefs, opinions, interests and motivation (p. 211).

The affective domain could be described simply as how we feel and the cognitive domains, how we think (Ebenezer & Zoller, 1993). In this thesis the term ‘construct’ is used to describe “a scientific concept that represents a hypothesized psychological
function” (Snow, Corno & Jackson, 1996, as cited in Koballa & Glynn, 2007, p. 75). When looking at constructs in science and learning, Koballa and Glynn’s discussion of the constructs, attitude and motivation, were in relation to “science-related thinking” (cognitive domain), “emotion” (affective domain) and “action” (psychomotor domain) (2007, p. 75). After extensive reading it seemed important to include ‘interest’ alongside attitude and motivation as an important construct.

In order to understand the factors that influence attitude, interest and motivation, Pintrich and Schunk (2002) discussed the importance for researchers to develop models to see how, why and when ‘affect’ precedes the ‘cognitive’ domain or ‘cognitive’ precedes the ‘affective’ domain.

The study of attitudes and interest in science is relevant to the teaching and learning of science and also to the outcomes of science (Jenkins & Pell, 2006). Simpson et al. (1995, p. 215) stated that many science education researchers saw the importance of studying students’ attitudes to science, as they believed that the “enhancement of attitude is related to a long term commitment to science”. There appears to be a strong relationship between attitudes, interest and motivation. When looking at attitudinal research, the terms ‘interest’ and ‘motivation’ are sometimes used interchangeably (Ramsden, 1998).

(i) Attitude

In 30 years of research into attitudes there is still a lack of clarity about the definition of attitudes (Osborne et al., 2003; Simon, 2000). Ramsden (1998) noted how important it is when researching ‘attitude to science’, to clearly define what is meant by attitude, as it is open to different interpretations depending on the context. Attitude is commonly defined as “a predisposition to respond positively or negatively to things, people, places, events or ideas” (Simpson et al., 1995, p. 212). Attitude to science was defined by Simpson, et al., as “a person’s positive or negative response to the enterprise of science” or put simply “whether a person likes or dislikes science” (p. 213). Bagozzi and Burnkrant (as cited in White, 1998, p. 101) saw attitudes to a concept such as science as “a person’s collection of beliefs about it, and ‘episodes’ that are associated with it, that are linked with emotional reactions” Therefore a person’s attitude to science can influence decisions about it such as
choosing science related subjects. White went on to speculate that an infant initially has no attitude to science until he/she experiences ‘episodes’ and images of it. For example if a child is told not to touch worms because they are dirty the child might associate the labels of ‘dirty’ with the ‘episodes’ (the worms), or if a child is told that a rainbow is beautiful the child might associate the label ‘beautiful’ with the ‘episode’ (seeing a rainbow). If the labels are positive the child may go on to develop a positive attitude to the ‘episodes’. A child may develop a positive attitude towards science but after the occurrence of ‘episodes’ with negative labels the child’s attitude may become negative towards those ‘episodes’ and eventually to science in general. White gave examples of such negative ‘episodes’:

- performing poorly in a science test;
- being unjustifiably reproached by a science teacher; or
- hearing that scientists have been involved in the development of nuclear weapons.

Osborne et al. (2003) discussed the complexity of ‘attitude’ and how it is important to understand that an individual’s attitude to science is made up of a large number of components rather than a single construct. Simon (2000) outlined a number of these components or variables recognized by researchers in the study of attitudes to science. These included “perception of the teacher, anxiety towards the subject, the value of science, self-esteem at science, motivation towards science, enjoyment of the subject, attitudes of peers and friends towards science, attitudes of parents towards science, the nature of the classroom environment, achievement in science and fear of failure in science” (Simon, 2000, p. 105). For the purpose of this study these variables have be considered in order to gain a full picture of a student’s attitude to science and to ascertain whether each student likes or dislikes the subject.

**Attitudes to science and science attitude**

Simpson et al. (1995, p. 214) stressed that it is important when considering attitude research in science to understand the difference between ‘science attitude’ and ‘attitude to science’. Simpson et al. described ‘science attitude’ as the way scientist’s thought and carried out their work and research. Lindahl (2003), drawing on the work of Gardner and Simpson et al., discussed how students in her study in Sweden revealed a ‘scientific attitude’ to science in that they used skills and displayed attributes such as “logic, open-
mindedness, curiosity and consideration of consequences in science” (as cited in Lindahl, p.14). Lindahl continued by saying that despite revealing a ‘scientific attitude’ many of the students in her study did not show an interest in school science and chose non-scientific subjects in upper secondary school.

**Measuring attitudes to science**

Ramsden (1998) highlighted the complexity of studying attitude. She stated that when we measure attitude we are using the subject’s actions and words and therefore we need to make assumptions. We cannot make a direct measurement of attitude because of the abstract nature of this construct. Ramsden (1998) highlighted the fact that it is therefore important to use a range of aspects when we collect data relating to attitudes, in order to look for underlying “trends and patterns” (p. 128). She suggested, when carrying out attitude research, that it is important to be able to cross check written and verbal responses, in order to increase reliability and validity in this complex area of research (p.134). To address these issues of reliability and validity in this research project multiple methods of data collection have been used.

**(ii) Interest**

Like attitude, interest is a construct that can be conceptualised in different ways (Lindahl, 2003) and it is also important to understand the affective and cognitive domains when attempting to define interest (Pintrich & Schunk, 2002). Kobella (1989, p. 2) described interest as a “learned response of liking or preferring”. Kleine (as cited in Ramsden, 1998) discussed interest as being defined as how much voluntary time someone was prepared to spend doing a task. This definition of ‘interest’ means that the construct could be measured by asking people to declare how much time they are prepared to spend on particular activities. This would be problematic as far as research is concerned, according to Ramsden, as people may state that they are interested in an activity without actually having engaged in the activity. As Kleine (as cited in Ramsden, 1998) mentioned, this means that during a research study someone could declare an interest in a task, but the observed behaviour that the person displayed towards the task may not be considered by the researcher to be indicative of an interest in a subject. Wall (as cited in Ramsden, 1998), highlighted this inconsistency between behaviour and interest. Wall discussed two
components of interest, “expressed interests” (likes and dislikes) and “manifest interests” (for example hobbies) (as cited in Ramsden, 1998 p. 127).

There is a clear distinction between interest and motivation (Gardner, 1985). People may be willing to declare interests but it is a different matter to be motivated to engage in the interests. Gardner stated that students’ interest in science might vary according to the way in which a student wishes to use the knowledge acquired in science. Continuing on this theme, Gardner devised four questions that could be answered to give insight into students’ interest in science.

1. how much students are interested in science to meet their personal needs,
2. how much do students want to learn about specific issues in science that relate to society in general,
3. how motivated are students to carry out academic work in science, and
4. how willing are students to follow a career in science or technology (as cited in Ramsden, 1998, p.128).

Considering these questions was helpful both during the early stages of this doctoral thesis and later in the study as it is important to be aware of the complexity of ‘interest’ and the inconsistencies that might occur when determining and/or measuring ‘attitude’ and ‘interest’, particularly in the devising of questions for interviews and surveys, in the carrying out of observations or when analysing and interpreting the data.

Theories relating to interest are still “rather young” when compared with the theories of the construct motivation (Pintrich & Schunk, 2002, p. 289) (see under ‘Motivation’ below). Educational researchers have divided interest into two categories, “individual interest” (or ‘personal interest’), and “situational interest” (Hidi, 1990). ‘Personal interest’ develops over time, tends to last longer than ‘situational interest’ and impacts on a person’s “knowledge and values” (Hidi, 1990, p. 551). However, ‘situational interest’ is stimulated by something in the environment, for example seeing or hearing something that triggers interest (1990) or focuses attention, and this form of interest may or may not last (Hidi & Harackiewicz, 2000). Although ‘situational interest’ and ‘personal interest’ are different forms of interest, they do not necessarily occur in isolation from each other, for example, the stimulation of ‘situational interest’ may eventually lead to ‘personal interest’ (Hidi,
1990, p. 551) or it may allow the motivation of unmotivated children. Hidi and Harackiewicz (2000), in their review of the literature surrounding interest, stated that ‘personal interest’ was one of the most important factors leading to motivation and learning. However as it might be unrealistic to cater for all the students’ ‘personal interests’, ’situational interest’ “might provide an effective alternative for teachers” who want to stimulate interest in their classroom (p. 156). Focussing on the ideas discussed by Hidi, Palmer (2004) explored to see if there was any relationship between ‘situational interest’ and attitude to science. In a study with primary teacher education students, looking at ‘situational interest’ and attitudinal change, Palmer found that sustained ‘situational interest’ could help improve students’ attitudes towards science. His study revealed that ‘situational interest’ and positive attitudes towards the subject occurred with the use of the following strategies:

- involvement by the use of ‘hands on’ activities;
- novelty by using “discrepant events activities and trivia”;
- meaningful activities, where students were learning how to teach science, and in some cases were able to increase their understanding of various scientific concepts that they would be required to teach in the future;
- group work; and
- personal anecdotes (p.905).

Palmer also found a positive link between ‘situational interest’ and other components of attitude such as “motivation, self-concept, enjoyment, perceptions of the teacher, and reduction of anxiety” towards the subject (p.905). He believed ‘situational interest’ could have valuable implications for science educators as it is relatively easy to create involvement, introduce novelty, and to stimulate interest and group work in “carefully chosen hands-on activities” in science classes (p.905). Palmer was careful to add that although there was a link between ‘situational interest’ and attitude to science in his study there was no way of determining how long these positive attitudes would persist after completion of the course.

In his study with grade nine students in Australia (N=224), Palmer (2007b) found that ‘situational interest’ could be aroused in science lessons by using various sources including some of the strategies mentioned above by Palmer (2004). The sources of interest Palmer (2007b) applied in this latter study were, “learning (referring to the students’ comments
indicating they were learning and understanding new things), choice, novelty/surprise, social involvement and surface features (such as colour or aesthetically pleasing activities)” (p.14). He found learning to be the most common source of interest of all.

This overview of the literature, which has explored and researched student interest in science, supports Pintrich and Schunk’s (2002, p. 289) conclusion that theories related to interest are rather young compared to motivation. This reinforces the importance of studying the factors impacting on students’ interest when looking at attitudes towards science.

When reviewing the literature the link between attitude and interest is apparent as is motivation and its link to interest and positive attitudes. In fact most laypeople and teachers tend to refer to interest when asked to define motivation (Pintrich & Schunk, 2002). Therefore it was important to clearly understand motivation, the theories associated with motivation and the importance of educators becoming aware of the strategies that increase motivation in the classroom in order to carry out the research for this thesis. As stated by Pintrich and Schunk (2002) the theories of motivation are well documented; some of these theories are outlined below.

(iii) Motivation

Like attitude and interest, motivation is a complex ‘overarching concept’ that is influenced by a number of factors (Harlen & Deakin Crick, 2002, p. 11) and also requires an understanding in the affective and cognitive domains. Simpson et al. (1995) described motivation as being “focussed more on the desire to act or not to act”, with the “behavioural component” being the emphasis (p. 214) while Pintrich and Schunk (2002) defined it as is: “the process whereby goal-directed activity is instigated and sustained” (p. 5).

Goal orientation is an area that is often considered when looking at the theories surrounding motivation. Harlen and Deakin Crick (2002) discussed how attention is given to any actions that assist people in attaining their goals or how attention might be directed away from actions that do not help in attaining goals. An important theory that contributes
to an understanding of motivation where an individual’s “personal characteristics or behaviour is involved” is ‘attribution theory’ (Harlen & Deakin Crick, p.12). An individual’s perception of the causes of success and failure is of central importance to the “development of learning” and therefore it is important in understanding motivation (p. 12) and what is behind the ‘attribution theory’. The three dimensions of cause are ‘locus’, ‘stability’ and ‘controllability’. The definitions of these dimensions are:

- locus is whether causes are perceived to originate from within the person or externally;
- stability is whether the causes are perceived to be constant or to vary over time; and
- controllability is whether the individual perceives that she or he can influence the causes of success or failure (p. 12).

Although Harlen and Deakin Crick (2002) were looking at how these dimensions related to motivation towards summative assessment, understanding these dimensions is important when looking at students’ overall motivation towards science generally. They discussed how characteristics of ‘ability’ and ‘effort’, which originate within a person (i.e. their ‘locus’), were commonly used as causes for success and failure towards learning tasks. They argued that the controllability and stability, of these causes, could be perceived differently amongst student learners. If a student attributes success to ability, which they perceive as stable (in that it does not vary over time), and that they cannot control that ability, they may respond positively towards a task such as a summative assessment task. However, if a student believes they cannot influence their failure as it is caused by their ability, which is ‘stable’ (does not change over time) and out of his or her ‘control’, it might result in a negative response to a summative assessment task (Harlen & Deakin Crick). Further if a student “attributes success to effort” and they perceive they are in ‘control’ of their success, because they perceive success as related to ‘effort’, the student might “deal with failure constructively” and be more likely to persist with a learning task (Schunk, 1991 as cited in Harlen & Deakin Crick, p. 12). These factors influence “a learners’ sense of efficacy in learning”; that is their capability to keep on learning (Harlen and Deakin Crick, p. 12).

Harlen and Deakin Crick (2002) described two sub-constructs of motivation:

1. ‘intrinsic’; and
2. 'extrinsic' motivation.

'Intrinsic motivation' is where the learner finds satisfaction from his or her own learning which leads to “self motivation and continued learning” and is required for life long learning (pp.12-13). They believed extrinsic motivation is where the learner is motivated to learn only in order to complete the task or the course, and does not relate to the content of the learning. This type of learning is stimulated by rewards such as the desire to gain reasonable marks, to receive a certificate, or not to fail. They stated that ‘extrinsic motivation’ means that learning would stop or effort would decrease, unless there is some sort of external reward.

Harlen (2003a) suggested motivation towards learning in a subject embraces interest in learning, self-esteem, ability to evaluate one’s own work, the effort put into learning, how much a student feels in control over learning, a students’ confidence towards learning and how capable one feels of succeeding (Assessment Reform Group [ARG], 2002). Harlen believed these factors are influenced by “pedagogy, home support, peer culture, curriculum, school ethos and assessment practices” (p. 3).

Britner and Pajares (2006, p. 486) also looked at motivation along the same lines as Harlen and Deakin Crick (2002) and discussed how students who have a strong belief that they can succeed in general science activities and tasks will be more likely to “work hard and complete them successfully” whereas students who do not believe they can succeed in the same tasks and activities will put minimal effort into them and avoid them altogether if they can get away with it.

Drawing on the work of Pintrich and Schunk (1996), Palmer (2007a) summarised the following theories of motivation and linked them to strategies to stimulate motivation in the classroom. These theories expanded on the ideas relating to motivation mentioned above (Britner & Pajares, 2006; Harlen & Deakin Crick, 2002); they are:

- the “expectancy-value theory” which involves two forms of beliefs: “expectancy belief” which is a “belief about one’s ability to succeed” and “value beliefs” where a student believes about the “extent to which the task is useful, enjoyable or relates to one’s self image”. These high value beliefs and
high expectancy beliefs can be stimulated in a classroom by the use of relevance, and teacher enthusiasm and encouragement;

- the "attributional theory" where students either believe they can achieve success through effort or where they believe that ability is what leads to success (discussed above). Strategies that can motivate a student to believe they can achieve through effort are achieving successes and receiving “praise and encouragement”.

- “self-efficacy” theory which is where students who have high confidence are more motivated to persist and complete a task. High self efficacy is stimulated in a classroom by students achieving successes and receiving encouragement;

- the “goal theory” which involves a student who strives to understand the content and this student would be considered to have a “mastery goal”. Alternatively students who perform in order to do better then their peers or to avoid failure would be classed as having “performance goals”. The promotion of mastery goals in a classroom is more likely to lead to motivation and would be stimulated by strategies such as “relevance, giving students choice, and the use of variety and praise”; and

- the “self determination theory” which involves intrinsic and extrinsic motivation (as mentioned above). An intrinsically motivated student finds activities enjoyable. Alternatively an extrinsically motivated student is only motivated to take part in an activity in order to receive a reward or to avoid failure. Intrinsic motivation is preferable in a classroom and would be stimulated by strategies such as students’ achieving successes, being given choices, and the use of novelty and social interaction in the programme” (Palmer, 2007a, pp.38,39).

Palmer (2007a) also included the two categories of interest outlined by Pintrich and Schunk (2001) and Hidi (1990), ‘situational’ and ‘personal interest’ (discussed under ‘Interest’ above). Palmer saw the importance of encouraging ‘situational interest’ in the classroom by practices such as allowing the students to achieve successes, providing novelty and presenting relevant content. Drawing on the theories outlined by Pintrich and Schunk, Palmer described a highly motivated student as having the following attributes where he or she would:

- be intrinsically motivated;
have established a personal interest in the topic;
• have achieved a mastery goal;
• have expectancy and self-efficacy beliefs where he or she believes achievement is a result of effort;
• have a belief and confidence in his or her ability to succeed
• hold value beliefs about the topic; and
• have an attribution of success related to effort.

Palmer described a student who lacks motivation as having the following attributes where he or she would:
• be extrinsically motivated;
• have performance goals;
• have low personal interests in the topic;
• have low self-efficacy and expectancy beliefs;
• have low self confidence;
• have little expectation that he or she is able to succeed;
• hold low value beliefs where no relevance in the topic is found; and
• hold a negative attribution where making an effort is not worthwhile as this student does not believe he or she has the ability to succeed.

Palmer went on to say that that these “beliefs, values and interests” are not fixed or unable to be changed; in fact a teacher could strongly influence these affective constructs by the strategies he or she implemented in the classroom (p.38). Some of these strategies mentioned above are discussed further in this chapter under ‘student motivation and engagement stimulated by excellent pedagogical practices’.

Self-esteem is discussed under motivation, as it is a very important emotional factor influencing this construct, but it also influences attitude and interest, particularly in relation to school science. Self-esteem involves an “individual’s emotions toward or evaluation of themselves” (Pintrich & Schunk, 2002, p. 305). According to Plummer (2001) a student with a reasonable level of self-esteem would be more likely to achieve to his or her full potential than someone who suffered from a low self-esteem. Plummer believed that self-esteem was about feeling competent and it was enhanced by a strong sense of self-worth. Self-worth enables a student to cope with successes and failure. Blascovich and Tomaka (as cited in MacArthur & MacArthur, 2004, p.1). discussed how self-esteem relates to a
students’ self-worth or how a student “values, approves of, appreciates, prizes, or likes him or herself”. The way students value themselves, their homes and school is often the “key to success in education” (Simpson et al., 1995, p. 211). Earlier researchers such as Bloom in 1976 and Brookover, Thomas and Paterson in 1964, believed the way students feel about themselves, is the most “important variable” in the education process (as cited Simpson et al., p. 213).

(b) Student Engagement

Interest and motivation are associated with engagement as illustrated below. Student cognitive engagement has been linked to motivated behaviour and academic performance generally in the classroom. Self-efficacy, an important component of motivation, was found to play a role in students’ cognitive engagement and performance (Pintrich & De Groot, 1990). In middle school English classrooms in a study in the United States (N=173), students who believed they were more capable appeared to persist more often with difficult or uninteresting academic tasks (1990, p. 37). Pintrich and De Groot also found that students who were motivated to learn were more likely self-regulating, were interested in their schoolwork, were more cognitively engaged towards their learning and sought to understand the material., Pintrich and Schunk, in their 1996 review, linked interest to deeper cognitive engagement and thinking (as cited in Palmer, 2007b). According to Skinner and Belmont (1993) engagement involved behavioural and emotional components. When a student is engaged their behavioural involvement towards learning activities will be sustained and they will display positive emotions towards the activity. These emotions included: “interest, enthusiasm, optimism and curiosity” (1993, p. 572). Skinner and Belmont saw the opposite of engagement as “disaffection” (1993, p. 572). When a student was disaffected he or she tended to show signs of boredom, depression, anxiety or sometimes anger, was withdrawn, and sometimes became rebellious towards the teacher or other students (1993, p. 572). Skinner and Belmont, also emphasized the importance of teachers fostering the learning environment to encourage student engagement. They listed a number of ways to encourage teachers to foster children’s basic psychological needs. These include “structure” by the use of clear communication, and adjustment of strategies to suit the needs of the students. Teachers can also provide “support” where they support the needs of the student and provide freedom to
allow the students to determine their own behaviours. The third is “involvement” where the teacher relates to their students in an affectionate manner and enjoys interacting with the students. The importance of changing the teachers' behaviour from one that “discourages” students’ engagement to one that promotes motivation and engagement was also discussed (Skimmer and Belmont, p. 580).

According to Pugh (2004) engagement can be influenced by three factors:

1. identity;
2. social context; and
3. understanding.

1. Pugh saw engagement in science as being associated with how a student relates to the subject or how a student ‘identifies’ with it. To illustrate this point, Pugh discussed the views of two students from his case study in the United States. This illustration is as follows: Ed believed he was a “science person” who was interested in science outside school and was engaged during his science lessons and his interest in science was sustained as he thought about the content of his science lessons outside school. Sarah saw herself as an “English person” who was not interested in science even though she achieved in the subject. Sarah appeared to show interest in some of the content of science but her interest was not sustained in that she was not truly engaged with the content and did not think about science outside school. However, Sarah stated how she often thought about literacy outside school and was truly engaged with the content in her English classes and experienced sustained interest in the subject. Pugh discussed how Ed’s engagement and sustained interest could lead him to engage in new activities relating to the topic, or to pursue an interest in science in some other way such as attending a science camp and taking further science courses.

2. Another factor relating to engagement, and supported by research was the social factor (Pintrich & Schunk, 2002 as cited in Pugh, 2004), which was evident in Pugh’s study where Ed’s peers and family seemed to support and encourage his interest in science, whereas Sarah’s family and friends appeared to support and encourage her interest in literature. The social factor was also connected to the identity factor where Ed who perceived himself as a “science person”, initiated social interactions with other people who were interested in science, while Sarah initiated social interaction with people who were passionate about literature.
3. The third factor associated with engagement according to Pugh was “depth of understanding”. Pugh discussed how Sarah appeared to learn the content of the science units at a shallower level than Ed who displayed a deep understanding in science. Ed was able to apply his understanding of conceptual ideas to examples in his life outside school; for example, after completing a unit of work on inertia and Newton’s laws, he was able to describe how inertia occurred in situations such as driving in a car or when his niece slid across a wet slippery floor. Ed described this event and said, “she just keeps going until the door acts on her” (2004, p. 189).

The two forms of engagement put forward by Pugh were: engagement towards what he described as “peripheral things” (2004, p. 194) such as novel activities, humour, or interactions with friends, or engagement with content where deep understanding and sustained interest occurred. He believed that it is important for researchers to pay attention to the difference between these two forms of engagement. Pugh discussed how Sarah revealed peripheral engagement where she was engaged with activities but not engaged with the content of the activities, whereas Ed experienced engagement with content. Pugh discussed how researchers need to be aware of how these two types of engagement differ and particularly how this engagement with content is applied to the students’ out of school experiences. We could also look at how engagement could be associated with the two forms of motivation where intrinsic motivation leads to levels of engagement associated with conceptual understanding and deep learning, whereas extrinsic motivation leads to ‘shallow’ rather than deep learning (Crooks, 1998; Kellaghan et al., 1996 as cited in Harlen & Deakin Crick, 2002).

This highlights the importance when researching students’ attitudes and interest, of gaining an overall picture of the students’ lives, both in school and out of school, in order to fully understand the depth of each student’s engagement in science.

**The Impact of Attitude, Interest and Motivation on Student Engagement**

One of the most relevant aspects for this study is to identify an environment that leads to interest in, a positive attitude to and motivation towards, science, and where students are engaged in both activities and content in the subject. Tytler (2007a) argued how schools need to place more emphasis on student engagement. He believed in order to
capture students’ interest and promote engagement in science teachers need to consider three aspects, their teaching approach, the classroom environment, and the students’ learning. These three aspects should be such that they provide meaning to the students, relate to their own concerns and connect with their life outside the school (p. 42). This is similar to what Pugh (2004) described as engagement with content (under ‘Engagement’ above). With this style of learning students may come to the realisation that science can help shape and improve their lives. Studies looking at learning strategies where science is in context with the students’ own lives, such as those outlined by Bennett, Campbell, Hogarth and Lubben (as cited in Tytler, 2007a), have concluded that these context-based approaches encourage motivation in science and lead to more positive attitudes towards the subject. The idea of placing the learning of science into a meaningful context not only enhances interest and student engagement but it also allows students to construct meaning and enhance their conceptual learning (Tytler, 2007a). It is also important to be aware of the problems that arise when students are not engaged in science such as “disaffection” (as mentioned under ‘Engagement’ above) which can lead to negative behaviour in the classroom.

(c) Overlap and Confusion Between Attitude, Interest, Motivation and Engagement

When reviewing the literature focussing on ‘attitudes’, ‘motivation’, ‘interest’, their interrelationships and their relationship with ‘engagement’ it was evident that as a researcher it is important to be aware of the complexity of these constructs. The following examples illustrate some of these complexities. Simon (2000) stated how we needed to be aware that when a student displays interest in science it does not necessarily follow that they will have a positive attitude towards the subject; for example, during an observation of a science lesson a student may display enthusiasm towards, and interest in, a topic (situational interest) but be reluctant to reveal a positive attitude towards science or state “publicly that they like science”, as this may not be the ‘popular thing to do’ (Simon, 2000, p. 106). Simon (2000) believed that in such a case the student might have been motivated to behave in a certain way, which is inconsistent with the attitude that the student held. Like interest and attitude the connections between interest and engagement can be difficult to interpret. Ramsden (1998) highlighted how students can be interested in an activity without actually having engaged in the activity. People may be willing to declare interests
but it is a different matter to be motivated to engage in the interests (Gardner, as cited in Ramsden, 1998). Also to add to the confusion there is a lack of broad agreement about the meaning of terms such as ‘affect’, ‘feelings’, ‘emotions’ and ‘moods’ (Pintrich & Schunk, 2002), terms often used when discussing attitude, interest, motivation, or student engagement.

As indicated there is also much overlap between the constructs. Motivation towards science is considered to be a factor affecting a student’s attitude towards the subject (Simon, 2000). ‘Interest in learning’ has been included as a factor influencing motivation (Harlen, 2003a) and according to Ramsden (1998), there is a relationship between interest and motivation. A link has been made between ‘situational interest’ and student attitude (Palmer, 2007a); also motivated behaviour towards a difficult task and interest in a task are considered to be factors of student engagement (Pintrich & De Groot, 1990). Skinner and Belmont, (1993) include interest as one of the positive emotions displayed when students are engaged in a task.

When Gardner (1985) discussed his second definition of interest, he made motivation a component of interest (as cited in Ramsden, 1998). However, Ramsden suggested that although there could be a link in some cases, the two constructs could be quite separate; for example, a student may be motivated to achieve in science but not be “interested” in the subject (p. 127).

In addition to ‘interest’ and ‘motivation’, Ramsden (1998) listed other terms that are often associated with attitudes and they include “curiosity’, views’, ‘images’, ‘beliefs’, ‘values’, and ‘personality characteristics” (p.127). She discussed the overlap and confusion with the definition of these terms (p. 127). Ramsden (1998) suggested that it is helpful looking at both “cognitive and affective dimensions” when defining attitude as terms such as ‘beliefs’ and ‘views’ are “located within this framework” (p. 128). She discussed how ‘beliefs’ relate closely to what people know or the “cognitive dimension” (p.128). ‘Views’ she believed take in both the “cognitive and affective dimension”, as they are concerned with the response of a person to “what they know”(p. 128). The terms ‘values’ and ‘personality’ could be used when attempting to describe “deeper levels of attitude”
according to (Oppenheim, 1992), as they are the most stable aspects that are involved in "affective responses" (as cited in Ramsden, 1998, p. 128).

There are differences between the affective constructs "attitudes, beliefs and values" according to Kobella (1989). He described how "values are rules" that influence the decisions people make with regard to what an individual perceives to be "right or wrong" (p.1). He went on to explain how values are complex and less easily changed than attitudes and he illustrated how beliefs can link "objects to attributes" (p.1); for example, the belief 'ice is cold', 'ice' being the object and 'cold' being the attribute (pp.1-2). He stated that a person has more beliefs than attitudes but far more 'attitudes' and 'beliefs' than 'values'. Kobella also highlighted the differences between attitudes, interest and opinion. He saw 'opinion' as being a 'cognitive' area, whereas he believed 'interest' was a "learned response of liking or preferring" (p.2). He described 'interests' as "usually being expressed by action verbs ...towards activities and objects" and that "in usage" the terms attitude and interest are "essentially synonymous" (Kobella, p. 2).

Although there maybe some overlap between attitude, interest, motivation and student engagement, when carrying out research, we need to be very clear of the differences. It is also important during research to understand the definitions of these key terms and be aware of the context underpinning their interpretation (Ramsden, 1998). Therefore for the purposes of this thesis, whilst bearing in mind the complexities of these terms and the huge number of factors impacting on them, the following definitions of 'attitude', 'interest', 'motivation' and 'engagement are used in this research project:

- **attitude** to science is “whether a person likes or dislikes science” (Simpson et al. p. 213);
- **interest** in science is seen as a measure of how the students actively respond to the subject or aspects of it (Kobella, 1989); and
- **motivation** is “where goal-directed activity is instigated and sustained” (Pintrich & Schunk, 2002, p. 5);
- **student engagement** is where a students’ behavioural involvement towards an activity is sustained and he or she displays positive emotions towards the activity (Skinner & Belmont, 1993, p. 572).
In a classroom environment in order for students to develop sustained interest in science and develop a positive attitude to the subject, he or she needs to display motivation towards science; such students will be engaged in both the activities and the content. Therefore it is essential as a researcher to be aware of the connection between these constructs and the significance of a classroom environment that promotes motivation and engagement. It is equally important as a researcher to be able to identify the factors that lead to students being unmotivated or disaffected in a classroom.

**(d) Linking and contrasting Attitude, Interest, Motivation and Student Engagement**

The diagrams on the following pages (Figures 2.1& 2.2) have been based on the various theories discussed above relating to the constructs, attitude, interest, motivation, and student engagement (see references below). Many of these theories relate to education in general although some are more specific to science education. The first diagram (Figure 2.1), attempts to highlight the many factors that influence these constructs. It also highlights the complexity of this area of research and how many factors are common to more than one construct, and in some cases are common to all constructs. This diagram is useful in that it highlights the influence of teachers and teaching practices, peers and family support and it draws attention to the impact of students’ self-esteem on attitude, interest, motivation, and student engagement.

The second diagram (Figure 2.2) is simplistic but attempts to illustrate the overlap between the constructs and it also includes the sub-constructs that have been devised in the literature. However it is important to be aware that there is a clear distinction between each construct; for example, if a student exhibits interest this does not necessarily lead to, motivation towards, engagement in, or positive attitudes towards, science. Research has shown that ‘situational interest’ can lead to a positive attitude in science. Motivation is related to interest and attitude, and positive attitudes, interest, and motivation, can lead to student engagement. Students who are intrinsically motivated will be more likely to show an interest in science and display engagement in the classroom.

The goal of science educators in the 21st Century is primarily for students to become scientifically literate and also for more students to choose science subjects in senior
secondary school leading to an adequate number of persons pursuing science careers. If educators recognize the many factors that influence these constructs perhaps this could be a step towards looking at practices that will move the students towards these ‘ideal’ constructs and sub-constructs, where in science classes students reveal intrinsic motivation, display engagement with content, present a positive attitude towards science generally and exhibit a ‘personal interest’ in the subject (both school science and science in society). The affective constructs “are not all fixed or unable to be changed” (Palmer, 2007a, p. 38) and it appears that attitude, motivation, and interest all relate to student engagement. It would be very unlikely for all students in a science class to display engagement with the science content or develop a ‘personal interest in science; finding ways to stimulate engagement even to peripheral things may be a start. It is beneficial for educators to also look at factors that stimulate ‘situational interest’ in science lessons as this has been found to lead to positive attitudes, and positive attitudes towards science may lead to engagement with content and in some cases develop into a ‘personal interest’ in science.
The following literature supports the representations depicted in figures 1 & 2:

- factors relating to attitude (Simon, 2000);
- ‘situational interest’ and ‘personal interest’ (Hidi, 1990);
- factors relating to interest and teaching strategies to stimulate interest (Palmer, 2004);
- factors relating to motivation and its sub-constructs: extrinsic and intrinsic motivation (Harlen & Deakin Crick, 2002; Harlen, 2003a);
- theories of motivation (Harlen & Deakin Crick, 2002; Palmer, 2007a; Pintrich & Schunk, 1996);
- factors relating to engagement (Pintrich & De Groot, 1990), emotions and disaffection (Skinner & Belmont, 1993), teaching strategies, engagement towards peripheral things and engagement with content (Pugh, 2004);
- link between engagement and attitude (Pugh, 2004);
- link between interest and motivation (Gardner, 1985; Harlen, 2003a; Hidi, 1990; Ramsden, 1988);
- link between motivation and attitude (Simon, 2000);
- link between interest and attitude (Palmer, 2007a);
- link between motivation and student engagement (Pintrich & DeGroot, 1990);
- link between interest and engagement (Pugh, 2004; Skinner & Belmont, 1993);
- the constructs influenced by teaching strategies applied (Palmer, 2007a); and
- situational interest leading to personal interest (Hidi, 1990).
Attitude, Interest, Motivation and Engagement and what Influences these Constructs and their Sub-Constructs
Figure 2.2

The Interrelationship between the Constructs, Attitude, Interest and Motivation and their Relationship to Engagement
There is further discussion relating to the important factors that influence attitude, interest, motivation and engagement in this chapter below under ‘Variables Contributing to a Decline in Positive Attitude to, and Interest in Science’.

At this point in the chapter an overview of the literature relating to the decline in students’ positive attitude to, and interest in science across the primary and secondary years is appropriate as it is the basis of the research study in this doctoral thesis.

4. Decline in Positive Attitude to, and Interest in, Science and the Impact of this Decline

This section of the literature review is divided into the following relevant subsections:

a) secondary School;

b) transition (or lack of it);

c) primary School; and

d) decline in student numbers for both choosing senior secondary school science and following a career path in science.

(a) Secondary School

Most science education researchers recognize that students’ negative attitudes to school science, is a problem. After reading a number of studies it appears that the decline in students’ positive attitudes towards science as they progress through secondary school is not confined to Australian Schools and has been an on going issue for the last two decades. In a study in the United States, Yager and Yager (1985, p. 352) reported that students found science less interesting as they progress through school. In another American study over ten years Simpson and Oliver (1990) also discovered a trend of deterioration of positive attitudes towards science through secondary school.

A recent International study, the Relevance of Science Education project (ROSE, 2006), involving participants aged 15 from a number of countries, focussed on attitudes to, and interest in, science education (Jenkins & Pell, 2006). The majority of English students
together with students from many other developed countries in the study did not reveal positive messages about their school science (Jenkins & Pell, 2006, p.47).

(b) Transition (or Lack of it)

The time when students move from primary into secondary school is quite an adjustment for many children particularly as they start specialist classes for a range of subjects (Ferguson & Fraser, 1998). This time is commonly referred to as transition, but the abrupt changes that students often experience during this primary/secondary interface is often far from ‘transition’. The trauma of this adjustment may be generally short lived (Jarman, 1990) but research studies suggested that there were significant problems associated when students moved from primary school science into secondary school science (Braund & Driver, 2005; Ferguson & Fraser, 1998; James & Smith 1985; Jarman, 1990; Keogh & Naylor, 2004; Simpson & Oliver, 1985). In the United Kingdom “significant and sustained regression in learning” occurred as a result of the changes when students moved from primary into secondary school and this was highest in science (Braund & Driver, 2005, p. 28). Studies revealed that the expectations of students in primary school regarding secondary school science were met with disappointment when they went from primary into secondary school. In an Australian study (Baird, Gunstone, Penna, Fensham & White, 1990), 93% of year six students (N=208) wrote in a questionnaire that they “enjoyed their science work and were looking forward to continuing it in year seven” (p.12). However, many of these students found science in year seven disappointing. In a study in Western Australia, Speering and Rennie (1996) found that students were more “enthusiastic about science at the end of primary school than they were in early secondary school” (p. 294). Harlen and Wake (1999) described how in primary school frequently science is unstructured and student-centred, where students are in control of their own learning and in secondary school the students find science more teacher-directed; they stated how students often find the secondary science laboratory “an environment with little relevance to everyday life” (p.8). Braund and Driver (2005) discussed the difference in teaching styles and the use of scientific language between primary and secondary school and how this impacts on students’ attitudes; they considered that there was a lack of recognition by secondary teachers of the students’ scientific knowledge acquired in primary school. They believed these factors impact on students’
attitudes to science. Jarman (1990) discussed how the repetition of work from primary into secondary school could lead to boredom and low motivation towards secondary school science. She stressed the importance of effective communication between the teachers of primary and secondary schools, to assist in the process of moving from primary to secondary school. It appeared clear that the time where students move from primary science into secondary science was an important period to incorporate into the research for this doctoral thesis.

It was interesting to read about a bridging programme designed by Braund and Hames (2005), which addressed the problems associated with the primary/secondary interface. The programme was implemented to create a smooth transfer from primary school science into secondary school science. The findings of the study revealed that students enjoyed being involved in the project and after completing the bridging course in years 6 and 7 were generally positive about school science and the move into secondary school. This information was helpful during the analysis and interpretation of the data for the research for this doctoral thesis in relation to the adjustment of moving into secondary school.

(c) Primary science

There is evidence to suggest this deterioration in positive attitude to science occurs in primary school. Pell and Jarvis (2001) in an English study ($N=978$) found that students’ enthusiasm for science declined through primary school. Pell and Jarvis’ (2001) results revealed that the participant students displayed a stable attitude to liking school generally over the same period. Murphy and Begg’s (2003) study in Northern Ireland ($N=1000$) supported this trend of a decline in enthusiasm for science through primary school and although to a lesser extent than Northern Ireland, students in Omani ($N=1000$ approximately) appeared to be less positive to science in earlier grades in primary school (Murphy, Ambusaidi & Beggs, 2006). Newton and Newton (1998) discussed how children form perceptions of science and scientists early and believed that these perceptions could impact on attitudes to science and curriculum developers need to be aware of this.

It is important for children to be exposed to scientific ideas in the primary years so they can build on their existing knowledge by being interested, stimulated and challenged
(Goodrum et al., 2001). It can be beneficial for students to learn basic scientific language, develop skills of enquiry and be introduced to key scientific concepts during the primary years when they are often keen and enthusiastic (Goodrum et al.).

As this deterioration in attitude is also happening in late primary school it seemed appropriate to incorporate attitudes to science in primary school as a component of the research for this doctoral thesis.

(d) Decline in Student Numbers for both Choosing Senior Secondary School Science and Following a Career Path in Science

Although some students achieve highly in science without displaying a positive attitude to the subject “enjoyment and interest in science” in addition to “positive achievement in science are likely to lead to a commitment to science through school” (Osborne et al., 2003, p.1072). There has been some concern relating to the current trend of reduction in numbers of students who choose to pursue science in senior secondary school in Australia (Goodrum et al., 2001). Rothapfel (2004) referred to a study commissioned by The Australian Council of Deans of Science undertaken by Dobson and Calderon in 1999 that revealed two disturbing findings:

- if the current rate of secondary school participation in chemistry and physics continues then there will be no enabling science in secondary school beyond 2020; and
- if the current rate of students selecting to study university science continues, there will be no chemistry, physics, as well as mathematics or engineering to support innovation after 2020 (as cited in Rothapfel, 2004, p. 24).

This situation is continuing and more recent figures revealed (Masters 2006a, as cited in Tytler, 2007a):

- a decrease from 1978 to 2002 in the year 12 biology cohort from 55% to just over 20%, in the chemistry cohort from 30% to 15%, and in the physics cohort from 27% to 12%;
- the number of university students studying physical and materials sciences nationally fell by more than 31% between 1989 and 2002;
• the proportion of Australian PhDs in science and engineering dropped from 46.9% to 37.2% between 1989 and 2002; and

• in 2001, only 1% of tertiary graduates in Australia were in the physical sciences, compared to 5.2% in the UK, and an OECD mean of 2.6% (2007, p.13).

On the 19th July 2006 it was announced by various media that a Federal Government audit had revealed that was a severe shortage of scientists in Australia. The prediction by the Australian Department of Education and Science was that there will be a shortage of 20,000 scientists and engineers in six years (Metherell, 2006).

It is recognized that the decline in positive attitude to, and interest in, science contributes to the reduction in numbers of students choosing science in senior secondary school and in those following a career in science. Simon (2000) suggested that how students perceive science and feel towards the subject was one of the determining factors influencing students in their decision to pursue science in senior secondary school. Simpson and Oliver’s (1990) results from a ten-year study in the United States confirmed this relationship between positive attitude and commitment to science.

Interest can be one of the most “important factors” influencing students’ choice of subject in upper secondary school according to Lindahl (c.2003, p. 14). She believed if students want to follow a career in science it is most important that they have positive experiences of the subject throughout their primary and secondary schooling. She warned that once a student loses interest in science it is very difficult to gain that student’s interest again; this finding was backed by Gibson and Chase (2002) who found in a longitudinal study in the United States looking at ‘enquiry based learning’ that attitudes towards science were formed in the early years of a child’s education and were difficult to change through the middle school years. Lindahl referred to some students in her study who displayed interest in certain career paths that required senior secondary science. However the students rejected these careers, as they did not wish to continue with science because they perceived it to be ‘boring’.

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Reporting on her study in England, Cleaves (2005) outlined three factors that influenced students against pursuing science in senior secondary school. The first was disappointment with school science, the second being lack of knowledge about occupations involving science and the third was that students perceived their science abilities were lower than they actually were.

When children enter the science classroom they cross from their own culture into the culture of a science classroom, with its scientific language and protocols (Aikenhead, 1996). Aikenhead described the ‘taught’ science curriculum as “more often than not leading students to a stereotyped image of science: socially sterile, authoritarian, non-humanistic, positivistic, and absolute truth” and suggested that this stereotyped image of science may negatively affect students in their career choices in relation to science (p. 11).

Goodrum et al. (2001) concluded by stating that schools should provide improved quality science education that will impact on all students’ lives. Science should be encouraging “our best young minds into science research and careers to make Australian industry internationally competitive” (p. 184).

5. Variables Contributing to a Decline in Positive Attitude to, and Interest in, Science

During the review of literature looking at attitudes, interest and motivation, a number of variables emerged that relate to students’ attitudes to, and interest in, science. These variables are discussed further under the following headings:

a) lack of relevance of school science;

b) science in society and school science;

c) gender issues, achievement in science, and ability in science;

d) parental attitudes;

e) attitudes of friends towards science; and

f) teacher influence, classroom environment and excellent pedagogical practices.
(a) Lack of Relevance of School Science

It is evident from the literature that students are finding that school science lacks relevance to their lives and this appears to be a contributing factor to students’ current lack of interest in the subject. Aikenhead (1996) believed that most students see “orthodox science” as having little or no relevance to them (p. 13). Much of the science presented in Australian secondary schools lacked relevance to the students’ “needs and interests” (Rennie, Goodrum & Hackling, 2001, p. 473). Only one-fifth of students found science lessons “relevant or useful” (p. 473). The science curricula in England and Wales did not allow students to reflect on why they are learning science or what they are learning” (Reiss, 2000, p. 144). Also reflecting on the curriculum in England and Wales, Millar and Osborne (1998) discussed how there is a large difference between what is being taught in schools and what is happening in contemporary science. They highlighted the lack of relevance of school science for many students, particularly those students in secondary school:

   too many young people complete their compulsory science education with apparent success, and yet still lack any familiarity with the scientific ideas which they are likely to meet outside school. Even for those who ‘succeed’ with the current curriculum, the kind of ‘understanding’ they achieve does not equip them to deal effectively and confidently with scientific information in everyday contexts (Millar & Osborne, 1998, p. 4).

This lack of relevance in the curriculum was evident in a comment by a teacher in a study that looked at teachers’ views on the secondary science curriculum in England and Wales: “kid’s can’t see the point of school science” (Leach, 2002). Osborne and Collins (2000) identified the lack of relevance of science to the students, particularly with subjects like chemistry and physics in their study in the United Kingdom. In her study in Sweden, Lindahl (2003) found that many students did not know why they were learning science. Issues relevant to the students’ local situations and “relating science concepts to everyday life” were factors students identified as leading to a positive experience in science (Ebenezer & Zoller, 1993, p. 183).

   It is important for students who are engaging in scientific discovery and enquiry relating to scientific experiences outside school, to take part in discourse with peers and teachers
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about these experiences (Gerber, 2001). Osborne et al. (2003) discussed how research highlighted the gap between views of teachers and their students, where students generally held a "high-tech, socially relevant perception of science" and the teachers held a "more theoretical de-contextualized version of school science" (p. 1062). Osborne et al. believed "to capitalize on students' interests, school science needs to be less retrospective and more prospective" (p. 1062). They discussed how recent studies have indicated that a science curriculum that relates to "students' interests and life-world experiences" leads to more positive attitudes in science for both boys and girls (p. 1070).

This problem of the lack of relevance of science was highlighted by Simon (2000) in her following statement: "the decline in the study of science post – 16 for all groups of students, indicated that we were failing to convince children that science is the most significant achievement of Western civilization" (p. 116). According to Reiss (2000) science should not only be encouraging scientific literacy and preparing students for life in the future but it should be absolutely relevant to the students' own world in the "here and now" (p.150). He concluded that unless science relates to the individual student's lives he or she would gain little from the subject.

In the Australian Education Review of science education, Professor Tytler stated how we need to "re-imagine science education to suit today's world" (Peacock, 2007, p.iii). He discussed how "there is a genuine mood for change across all sectors" (p.iii). Making science relevant to the students' own world is one of the key factors leading to student engagement and positive attitudes towards the subject.

The following comments from teachers recorded during forums at the Australian Council for Educational Research (ACER) conference in 2006 (Tytler, 2007a), are included below as they capture the essence of relevant science:

- "tap into kids interests by looking at using technologies such as mobile phones;
- use open-ended projects related to real-life issues valuing creativity, for instance the solar car challenge;
- in our school, the curriculum is untied – all units are of relevance to students' lives, for instance a unit on science and art pigments, solvents etc. The units give choice so students own the topic;
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• (set up) a winemaking unit involving partnership with local industry;
• study the science of sport – interpret the intent of the syllabus and depend less on the text book;
• an example: a country area using agriculture as the setting for science teaching;
• ask students before choosing contexts; use contemporary science issues; more debate; research in the classroom; interdisciplinary topics;
• develop skills in students on researching issues; courses are too content prescribed – they should be issue based; and
• open up the curriculum more so schools can write their own courses; teach important daily issues; analytical thinking should be taught and developed” (2007a, p.43).

The teachers at this conference discussed how the “rigid nature of the science curriculum” and “conservative forces in science curriculum change” tend to prevent teachers and schools from trialling practices such as those addressed above or developing their own curricula (Tytler, 2007a, pp. 43, 44).

The problem of school science being unrelated to science in society, was reflected by Holbrook (2007), the Secretary of the International Council of Associations for Science Education, in the following statement from his presentation at the Conference of International Council of Associations for Science Education (ICASE):

Whereas change in school science is slow, the pace of scientific and technological development within society is great, so much so that there is a danger that the changing world leaves science education behind. This is not only in terms of content and its related conceptual understanding, but also in its approach, its field of operation and the skills demanded of the teacher (p.1).

Like Tytler (2007a) Holbrook was also calling for a ”rethink of science education” (p.3). Holbrook outlined a number of points that related to making science more relevant from the students’ perspective and encouraging motivation towards science. The following points are taken directly from his ICASE presentation:

• “students need to see the relevance of the learning, as it applies to them personally (their own lives, their career expectations, the wishes of their parents), or the relevance as it applies to society (wishes of the community, employers, the school, the curriculum);
• while science provision in school, i.e. science (or science and technology) education, is expected to guide students to achieve the goals of education through science, there is also the motivational factor to consider;
• students learn when they are motivated. Making the science education provision interesting to students, illustrating that the provision is important in helping determine a career, and showing how it is of importance for them as a responsible member of society, is important; and
• it is important for students to better appreciate the relevance of the science component in their education” (Holbrook, 2007, p. 2).

(b) Science in Society and School Science

A number of researchers, when looking into the attitudes of students towards science, discussed the importance of taking care to make a clear distinction between ‘school science’ and ‘science in society’ (Osborne et al., 2003; Ramsden, 1998; Whitten, Tuck & Haigh 2003). Surveys have shown that students’ attitudes to ‘science in society’ are positive even though numerous studies reveal the negative attitudes of students towards ‘school science’ (Osborne et al., 2003). The findings from the ROSE study generally supported science and technology in society (Jenkins and Pell, 2006). However the picture for school science is different, particularly in England and other developed countries: although students regarded science as important the majority preferred other subjects to science and this view was more common amongst girls (Jenkins & Pell, 2006, pp. 47-48).

A number of scientific and technological developments have resulted in negative environmental and societal consequences (Millar & Osborne, 1998). These include “DDT, Chernobyl, Thalidomide, CFCs, and the depletion of the ozone layer” (p. 4). In addition scientific developments such as “genetic engineering and cloning” have lead to public suspicion and unease regarding the implications of these developments (as previously discussed above in ‘Science Literacy and the Curricula’). It is important to be aware of the negative attitudes towards aspects of science within the community when carrying out attitudinal research into science. Jenkins and Pell (2006) referred to some English students who saw environmental issues as being exaggerated and leading to too much anxiety but they also stated that other students appeared to have strong interests with these matters.
Data in this ROSE report revealed that many English students, although generally believing that threats to the environment were relevant to them, were only moderately interested in learning about environmental issues, apart from learning about the health risks associated with mobile phones or the protection of endangered species (Jenkins & Pell, 2006). However, in a study looking at students’ attitudes to the utility of science, George (2006) found a correlation between students’ declining attitudes towards the utility of science in society and students’ attitudes towards science generally over the middle school years. He believed that when the importance of science in society is revealed to the students then they are more likely to become interested in, and pursue careers in, the subject.

Looking at a different perspective relating to students and science, Hendley, Stables and Stable’s (1996) found science to be the most commonly disliked subject in secondary school but it was also the most commonly liked subject. Hendley et al (1996) suggested that science, like maths could be described as a “love-hate” subject (p. 184). The researcher needs to be aware that although science is unpopular with many students, some students are passionate about the subject and find it relevant and meaningful to their own lives; these students could be said to have a ‘personal interest’ in science. Determining relevant issues in science that students find meaningful and that will lead to motivation and engagement is an important task for science educators.

**(c) Gender Issues, Achievement in Science, and Ability in Science**

Gender was the most significant factor influencing attitudes to science according to Osborne et al. (2003). Australian and international studies have found gender differences in students’ interest in, and attitudes towards, science (Martin et al., 2000), particularly during the late primary and early secondary years (Baird et al., 1990; Ferguson & Fraser, 1998; Jones, Howe & Rua, 2000; Simpson & Oliver, 1990). A number of studies have revealed that girls lose interest more so than boys (Hendley, Parkinson, Stables & Tanner, 1995; Simpson & Oliver, 1985; Simpson & Oliver, 1990). When students were asked to rank all their subjects in order of preference, Colley, Comber and Hargreaves (1994) found boys in middle school ranked science higher than girls ranked the subject. In fact boys liked physical education most, followed by science and girls liked French least, followed by
science. This trend of girls losing interest more so than boys has not been universal and the gap may be narrowing (Osborne et al., 2003). No decline in attitude was evident in a primary/secondary interface study in New Zealand, with girls from an ‘all girls’ secondary school (Whitten, Tuck, & Haigh, 2003); in fact the girls’ attitude to science became more positive over this period (Discussed further below under section [f] ‘Teacher Influence and Classroom Environment’). Murphy & Beggs (2003) found Irish boys in primary school were less enthusiastic than girls about science lessons and experiments while Lindahl (2003) found boys to be as critical of science teaching as girls.

A “downward spiral effect” was identified by Asoko (2002, p. 112): this was where a lack confidence in science lead to low achievement in the subject, which then lead to a feeling of lack of success, possibly resulting in a further lowering of confidence. Many teachers agreed, in another study that a lack of achievement in science could affect a students’ attitude towards the subject (Fraser, 1982, as cited in Whitten et al., 2003). In a longitudinal quantitative study by Jo and Song (2003) in Korea, with students in years 7 to 9, 142 students were asked to respond to the question ‘why do you study science in school’. It was found that the responses differed markedly between low and high achievers and gender. Low achievers became less sure of why they were studying science by year nine, whereas a large number of high achievers continued from year seven to year nine to answer with an academic reason, such as ‘to enhance logical thinking’ or ‘science is interesting to me’. There was also a gender difference in the responses, as more girls’ views changed from an academic view to a view of how science related to their lives, future, career or society. More boys held on to their academic view or changed from an academic view in year seven to a view of being unsure why they were studying science by year nine.

There appeared to be a moderate relationship between student (science) ability and perceived ability, and attitudes towards, and interest in science (Hasan, 1985; Lindahl, 2003; Osborne et al., 2003). According to Lindahl (2003) students tended to perceive that they have a low ability in science when they found science difficult and this negative perception could influence the students’ achievement, attitude and behaviour. Students who perceived that they had higher science ability, had better self-concepts, and therefore were motivated towards achieving (Hasan, 1985). Boys were found to perceive themselves
as having higher abilities in science than girls (Andre, Whigham, Hendrickson & Chambers, 1999; Jovanovic & Steinbach, 1998) and gender differences were found with students’ experience, attitude and perceptions of science (Jones, Howe & Rua, 2000). In response to these findings Jones et al. (2000) urged teachers to present science to be equally engaging and appropriate for both girls and boys and encourage girls and boys to participate in practical activities with a ‘minds on’ approach, for example, where students are encouraged to think about scientific concepts and make sense of them by relating them to familiar experiences (Keogh & Naylor, 1996). Many students in Cleaves’ (2005) study perceived that they were not “clever enough” to pursue science in senior secondary school (p. 482) - this included those students who were high achievers in science. Science is a subject that is commonly thought to be more difficult compared with other subjects (Lyons, 2006). Lyons highlighted how the interpretation of the word ‘difficult’ needs careful attention as students may be referring to the “irrelevance of content” and the frustration associated with memorization, or how a teacher may cause science to be more difficult by the way he or she presents it, rather than the “intellectual challenge” of the subject (pp. 603, 603). He also assumed that students who perceive science to be difficult as a result of their school experiences would most likely continue to perceive science as difficult even as an adult.

Reviewing this literature on gender, achievement, and ability, highlights the importance of looking at these variables when considering attitude and interest research.

(d) Parental Attitudes

Parental attitudes combined with personality traits influence early experiences in school science (Simpson & Oliver, 1990). Andre et al. (1999) in an American study in Iowa, suggested that parental perceptions of the abilities of their children could be a strong influence in how the students perceive their own abilities and this in turn could influence children’s “expectations for success, achievement, interest in school subjects, and future careers” (1999, p. 742). They found parents of primary students perceived science to be more important for boys than girls and they discussed how perceived importance of science by parents might influence the encouragement that is given to their children in science. Hasan (1985) found a relationship with fathers’ education level and their sons’
attitude to science but there was no relationship between mothers’ educational level and her child’s attitude to science. In his five-year longitudinal ethnographic study, Reiss (2000) conducted interviews with parents of 21 students, assisting him in gaining an overall picture of each student in his study. The data from this study was informative and Reiss’s study played a major role in influencing the design of the research methods for this doctoral project. Looking at this relationship between parental attitudes and the attitudes of students to science, together with the readings about the significance of parent interviews in Reiss’s research, confirmed the importance of involving parents in this research project.

(e) Attitudes of Peers and Friends Towards Science

In a study in the United States, Talton and Simpson (1985) found a significant relationship between the attitude of peers towards science and the attitude of individual students towards science. The authors claimed that this relationship increased over the primary/secondary interface years and through the middle school years. Talton and Simpson discussed the “synergistic effect” of students’ attitudes (p. 23). This is where students’ attitudes had a “snow balling effect” and if some students became negative towards science then others will follow resulting in a “negative group attitude”. This same ‘snow balling’ effect could occur when a number of students’ attitudes towards science became more positive therefore encouraging a general positive attitude. This synergistic effect would surely have implications for educators seeking to improve students’ attitudes to science. In the planning of this doctoral thesis the influence of peers on attitude was taken into consideration during observations and by the use of focus groups that consisted of two to four students of the same sex.

(f) Teacher Influence, Classroom Environment and Excellent Pedagogical Practices

Teacher Influence and Classroom Environment includes a number of sub-headings relating to the topic, these are:

i. teacher influence and classroom environment;

ii. student motivation and engagement stimulated by excellent pedagogical practices;

iii. the use of ICT in the classrooms;
iv. problem based learning and other pedagogies;

v. professional development for teachers and teacher training to support and encourage teachers to undertake innovative pedagogy; and

vi. a study where students' attitudes became more positive towards science as they progressed through school.

(i) Teacher Influence and Classroom Environment

Teaching quality is one of the most important factors related to students' attitude to science (Brok, Fisher & Scott, 2005; Ebenezer & Zoller, 1993; Woolnough, 1994) and this variable, influences students with their decisions to pursue the subject in senior secondary school (Woolnough, 1994). Teachers need to be aware of how their relations with students, particularly during instruction, would impact on the students' opportunities for learning (Darby, 2005). Many teachers, according to Osborne et al (2003), although being knowledgeable in science, failed to present a range of learning opportunities or to effectively communicate science to their students. Teachers should be committed to giving students a positive experience of science, “to ensure a love of learning in science” and seek to create an environment that is ‘comfortable’ and leads students to continue with science throughout their schooling (Rothapfel, 2004, p.24). Much discontent amongst students and their parents with regard to teaching practices in science was found in Osborne and Collins' (2000) study. They concluded by saying:

The recruitment of effective teachers is vital to sustaining the subject and requires urgent and immediate attention by the science education community. Failure to address these issues runs the risk of increasing the separation of science from its future public and its future public from science (p.30).

The change in relationship between students and teachers after moving from primary into secondary school has been noted as a variable influencing students’ attitude to science and possibly their attitudes to other secondary subjects. This was the most frequently mentioned factor in a study in Western Australia conducted by Speering and Rennie (1996) where students' attitudes to science became less positive after moving from primary into secondary school. They discussed how students spend less time in the specialised classes in secondary school and argued that it is therefore difficult for students to form close relationships with their teachers like the student/teacher relationships developed in primary
school. This change in student/teacher relationship occurs in the early stage of secondary school when students are forming their attitudes towards secondary science. This adjustment to a different style of teaching in secondary school was discussed by Fraser (1995), who highlighted the change from a small personal class size in primary school to a larger less personal class size in secondary. There was also a difference in perceived classroom environments between classes taught by males and those taught by females, reported by Lawrenz (1987).

Generally practical work is very popular with students (Cleaves, 2005). In a study by Braund and Driver (2005, p. 83) students preferred practical work to written work or reading in science as they found it “fun, enjoyable and motivating”. However much practical work in science in secondary schools appeared to be more teacher-directed than practical work in primary schools (Fraser, 1995; Goodrum et al., 2001). Ebenezer and Zoller (1993) stated that “student-directed experimentation and exploration” encouraged interest in science (p.183). The importance of student-centred practical work was highlighted by Harlen and Wake (1999) who stated that undertaking practical science where students experience science ‘first hand’ such as carrying out open-ended investigations is essential in science classrooms. Student-centred investigations where students are investigating aspects of science that is relevant to their lives could enhance student motivation and interest. Tytler (2007a) outlines a number of meaningful student-centred science projects that are being carried out in schools enabling students to be actively involved in investigative science with real life issues and where school science is linked to industry and/or the community.

A number of studies revealed students’ dislike for excessive note taking in secondary science (Ebenezer & Zoller, 1993; Ferguson & Fraser, 1998; Osborne & Collins, 2000; Palmer, 2007b; Speering & Rennie, 1996). Learning from the textbook and ‘memorizing facts’ have also been identified as practices disliked by students (Ebenezer & Zoller, 1993, p183). Lindahl’s (2003) student participants remarked on the dull science laboratory atmosphere, with textbooks full of facts and “very serious teachers”. One of her student participants asked, “Is it not allowed for science teachers to laugh?”(p. 14). Osborne and Collins (2000), in a study looking at parents’ and pupils’ views of school science, found that science teaching in England tends to be “content-dominated and assessment driven”
(p.30). They went on to say that teachers rush their students through the syllabus, they often repeat material, they use techniques such as copying notes, and they provide little or no time for practical work or discussing contemporary science issues. Elicitation of students' prior knowledge about topics and formative assessment are strategies accepted by science educators as a central part of planning (Asoka, 2002). Asoko believed these strategies assist the teachers to adapt their lessons to meet the needs of the learners. Gaining knowledge of the students’ ideas at the commencement of a unit of work could avoid repetition of work covered in previous years. However some teachers have problems identifying ways to gain this information. Millar and Murdoch in their 2002 publication (as cited in Asoko, 2002), highlighted elicitation strategies to initiate discussion, such as the use of concept mapping, annotated drawings, sorting and classifying activities, and true/false cards. Concept cartoons have also been suggested as techniques for this purpose (Asoko, 2002; Keogh & Naylor, 1996).

It is important for teachers to make their instructions clear in science (Lindahl, 2003). Lindahl believed that lack of understanding of what is expected in science laboratory work or in science generally could lead to students “doubting their own capabilities and losing interest” (p. 16).

When the work in the classroom “lacked demand” some students became bored, but if the work was too difficult and over demanding then students would become confused and this could lead to a negative attitude towards science (Jarman, 1990, p. 22). This revealed the balance that is required to achieve an engaging learning environment. Baird et al. (1990) highlighted the need for teachers to provide “an adequate level of challenge” to avoid boredom through lack of challenge (p. 17). The word ‘boredom’ appeared in a number of studies involving students’ attitudes to science. Baird et al. discussed how students regularly use this word with reference to aspects of school science. They suggested how the word ‘boredom’ could be used to describe different ‘underlying meanings’. For example boredom in science might result from a lack of challenge, a lack of interest and motivation in science, or as a result of a lack of achievement and fulfilment. This highlights the need for careful interpretation and the use of other techniques to discern the underlying factors when this response occurs.
Chapter Two

Classroom experience is seen to be one of the most significant variables in influencing attitude to science (Simpson & Oliver, 1990). Fraser (1995) in his review of research looking at ‘exemplary teaching’, highlighted a number of common features including:

- the creation of classroom environments favourable to students;
- “well ordered classes”;
- a relaxed classroom atmosphere;
- “pleasant interactions with students”;
- using subtle humour with the students;
- elicitation of student understanding of scientific concepts; and
- a respect for student ideas (p. 518).

It is important to include the perceived learning environment as a variable (including classroom environment and teaching style) in researching attitudes to science (Ferguson & Fraser, 1998).

Involving teachers in the research process can be helpful in gaining a picture of student attitudes to, and interest in, science, from all perspectives. Reiss (2000) interviewed the teachers of the 21 student participants adding to the richness of his data to gain an understanding of the teachers’ perceptions of each of his participants and how they experienced school science.

(ii) Student motivation and engagement stimulated by excellent pedagogical practices

According to Palmer (2007a, p. 38), “high quality teaching can change students’ goals and beliefs for the better”. There is not one strategy to motivate students in science rather there are a number of teaching practices that if carried out regularly would encourage students to become motivated and engaged during science lessons (Palmer, 2007a). Even though some of the practices discussed below relate to other sections within this literature review it was considered important to include them together as I believe Palmer captured the essence of teaching excellence, in his paper published for practicing teachers (2007a).

Drawing on the work of Pintrich and Schunk, Palmer, (2007a) discussed the beliefs, interests and attitudes that influence motivation. It is important for teachers to set clear
goals at the beginning of a lesson so the students know exactly what is expected of them and that explanations are clear and simple.

Allowing students to experience success was considered vital to encourage motivation and engagement in the classroom. Motivation and more positive attitudes can result from students constructing more understanding in a subject and experiencing successes, whereas when students struggle with conceptual knowledge they may hold the belief that the subject is beyond their grasp. The successes could be learning something new or being able to manipulate equipment effectively to achieve a result in a practical task. Therefore it is important to provide 'hands on activities' where the experiment works, the equipment is properly maintained and clear instruction is given on its use.

Encouraging students to discuss or ask questions in the classroom and providing an environment where students feel comfortable to express their ideas also leads to student engagement. This method to encourage engagement could be achieved if the teacher smiles and uses the students’ names. The use of body language that indicates the teacher is listening to the students, such as nodding and providing praise when students attempt to express ideas or answer questions, are also good strategies to encourage student engagement.

Designing questions that students are capable of answering will contribute to students’ feeling successful and could lead to a sense of self worth. Student success could also be achieved by providing assessment tasks that are flexible. These assessment tasks could be challenging for more capable students but designed so all students are able to pass in science even if it means allowing students to resubmit and eventually pass the subject.

The use of visual aids to explain scientific concepts, novelty demonstrations, extraordinary science with computer simulations or amazing facts can also encourage student engagement. Choice in the classroom was another method mentioned to empower students and lead to an increase in motivation.

The most obvious strategy and one which many researchers in science education agree is essential to increase interest in science, was learning through enquiry, for example, being
given the chance to choose and design experiments and equipment. Palmer also included making the content relevant to the students' lives (as discussed under 'Lack of relevance of school science' above) as an important method to increase motivation and student engagement and he gave an example of ‘product testing’ where students design and carry out experiments to test everyday products. He also included the use of personal accounts of real life situations or reference to the media to enhance science themes as ways of increasing the relevance of science. Adding variety to science lessons also was encouraged with strategies such as dramatisations of scientific concepts, model making, or taking the students outside to conduct activities in the school grounds.

Making use of school gardens when studying biology or carrying out physical activities to demonstrate science concepts was suggested. Social interaction where students work in groups, take part in presentations and carry out projects were methods recommended to increase motivation. Equipment such as interactive white boards for presentations and recording of group results could enhance this student-centred collaborative approach. The enthusiasm of the teacher and particularly the use of humour could greatly add to a classroom atmosphere that leads to motivation and engagement according to Palmer (2007a).

Supporting Palmer’s (2007a) ideas, Britner and Pajares (2005) stated that teachers should pay careful attention to students’ self-efficacy in science and provide opportunities in order to increase students’ successes in the subject. This action could ultimately encourage students to make decisions about their future studies and career choices in science based on interest and ability. Presenting “authentic enquiry-oriented science investigations” was suggested as a method to provide the students with experiences that will promote science self-efficacy beliefs (p. 494). It was recommended for teachers to ‘scaffold’ these activities and provide challenging experiences, but at the same time a level that will allow achievement by all (in some form), to enable students to experience the feeling of success rather than failure.
(iii) Use of ICT in Science Classrooms

When students used information communication technology (ICT) during science lessons it had a positive influence on their enjoyment of science (Murphy, 2003). However, there has been little research into how ICT can enhance attitudes to science, science skills and concepts (Murphy, 2003). Murphy (2003) in a literature review into the use of ICT in the primary science classroom suggested teachers make use of ICT in the science classroom including the use of computers (including laptops), scanners, digital cameras, printers, data projectors, interactive whiteboards, robots, data loggers and digital microscopes. Murphy outlined examples where ICT could enhance science lessons these include the use of:

- digital photos of experiments to enhance the students' confidence to discuss and give clear descriptions of their results;
- presentation tools such as ‘Power Point’ to encourage students to present information to their peers which could lead to improved communication skills and a deeper understanding of conceptual information as a result of rehearsing their explanations;
- CD-Roms and exploration of the Internet to enhance interest in science (ensuring the students are carefully directed and monitored by teachers);
- data loggers and digital microscopes which would result in students taking part in activities that are closer to scientists’ practices and could encourage curiosity and cooperative group work in science. However teachers are not always confident to use data loggers and sometimes the sensors are too fragile for regular use by students.

The use of ICT aspects in the classroom such as simulations, computer based modelling and research using the Internet allow students to gain experiences “relating to science in the real world” (Webb, 2005, p. 728).

Tytler (2007a), drawing on the work of Lemke, argued that students in the 21st Century have access to sophisticated methods of communication in their everyday lives. Technology is available to teachers why not make use of it in science to enhance student engagement? The use of “computer simulations, audio, video, graphical images,
animations, three-dimensional models, virtual worlds” in addition to “spoken language and text” can link science to the multi-modal communication that students’ experience in their everyday lives and allow scientific conceptual ideas to be represented using a range of technologies (as cited in Tytler, 2007a, p. 37).

The use of ICT in the science classroom is an important factor to consider during the research for this doctoral thesis.

(iv) Problem Based Learning and other Pedagogies

There are number of teaching pedagogies that have been introduced into science classes to increase motivation and understanding in science such as enquiry-based learning. These teaching styles encourage student-centred learning where students are encouraged to question, explore, investigate and discuss their ideas to build on their knowledge and understanding in science. In classes where enquiry-based learning is implemented, the students are responsible for their own learning and the teacher acts more like a facilitator to scaffold and guide the students in their learning. Enquiry-based learning can increase interest towards, and motivation to make an effort in, science (Gibson & Chase, 2002). A number of these pedagogies are consistent with the theory of learning known as constructivism where students “construct rather than absorb new ideas” (Skamp, 2007, p.10). However, there has also been criticism of the constructivist approach to learning by educators such as Bereiter, 1994, Mathews, 1995, Osborne, 1996, Phillips, 1996 (cited in Skamp, 2007, p. 14). Tytler (2007a) highlighted one of the problems associated with theories of learning that concentrate on individual student’s conceptual understanding and encourage elicitation of students’ prior knowledge. He believed these theories are lacking in strategies that will assist the students to move from a “naive” conceptual idea to scientific understanding (p.34).

Smith and Mitchell (2007) described an approach to learning, similar to enquiry-based learning, known as ‘problem-based learning’. This is also a pedagogy that is student-centred but it encourages students to establish issues and problems to be explored. They also stated that reflecting on the students’ learning at the end of the unit of work is emphasized in this approach. A teacher who trialled ‘problem-based learning’ in her
classroom admitted that teaching using this method took some adjustment and that it was demanding, but at the same time it encouraged the students to be motivated in their science lessons, take responsibility for their learning and “engage in deep learning” (Smith & Mitchell, 2007, p. 5). Smith and Mitchell saw the biggest problem in implementing this learning approach was the fear that many teachers held which prevented them from moving outside their ‘comfort zone’. Teachers often resisted changes to their pedagogy if they believed their own traditional teaching approaches enabled students to learn. However although many traditional teachers do inspire and engage students in science, in order to address the current problem of lack of interest, motivation and engagement in many science lessons, maybe approaches that encouraged students to take control of their learning need to be taken seriously by teachers. A step towards changing a teacher’s approach towards their science pedagogy according to Olitsky (2007) was to view science learning more as a social pursuit rather than an individual pursuit. If we look at how scientists work they often work collaboratively in teams with other researchers and industries to solve global problems, in contrast to the individual scientist of the past working alone to find a solution to a problem (Peacock, 2007). Olitsky (2007) talked about how meaningful group work and genuine interaction that encouraged feelings of group membership could encourage engagement in science and promote sustained interest in the subject.

During his presentation at the Conference of International Council of Associations for Science Education (ICASE), Holbrook (2007) outlined an approach that addressed some of the problems associated with the deep learning of difficult scientific concepts; and it focussed on scientific and technological literacy (the STL approach). As the name suggests the theory identifies with scientific literacy and is defined as “developing the ability to creatively utilise sound science knowledge (and ways of working), in everyday life, to solve problems, make decisions and hence improve the quality of life” (Holbrook and Rannikmae, cited in Holbrook, 2007, p. 3). The philosophy underpinning STL addresses and attempts to resolve “societal issues or concerns” relevant to students and makes sure the scientific conceptual learning is embedded within these activities (p. 5). He saw constructivism at the very heart of STL and believed that this type of learning theory where teachers elicit the prior knowledge of the students necessitates their involvement. He suggested, three ways forward: that there was a need to allow students to participate in
relevant issues related to the “social context for science learning”; more student activities where students take part in self-learning could be implemented; and teacher centred approaches be replaced by student involvement (Holbrook, 2007, p. 5). Holbrook also discussed how there needs to be more “potential diagnostic measures of the effectiveness of the teacher” (p.5).

(v) Professional Development for Teachers and Teacher Training to support and Encourage Teachers to Undertake Innovative Pedagogy

In order to teach using innovative practices such as the enquiry-based approach it is important for teachers to become knowledgeable and familiar with the content and processes that they plan to implement in their classrooms (Jeanpierre, Oberhauser & Freeman, 2005). In the United States Jeanpierre, Oberhauser & Freeman carried out a case study looking at secondary teachers (N=20 [of 44]) who had undertaken professional development which involved taking part in a science research project themselves using the enquiry-based approach. This way the teachers were able to learn the skills to successfully facilitate the project into their own classrooms. Students (N=86) were also involved in the project to allow the teachers to observe how they reacted to this learning style. This professional development programme allowed the teachers to incorporate enquiry into their classroom, not just as an extra activity, but also as an “integral part of their classroom practices” (Jeanpierre, Oberhauser & Freeman, 2005, p. 686). They saw the need for more research to look at strategies to convince teachers who are teaching using a traditional approach on the value of teaching with an ‘enquiry-based’ approach and strongly recommended support for teachers who take on new innovative pedagogies.

Science educators who attended an Australian Science Educators Research (ASER) conference in 2006 where the crisis in science education in Australia was addressed, agreed that in order to address the problem of students’ disengagement in science, there needs to be “an urgent re-thinking of the way science is taught in Australia” (Ainley, 2006). These education researchers believed that teachers are vital in addressing this problem of lack of student interest towards science. They stated that teachers need to adopt innovative pedagogies, knowledge and commitment to science in order to address important issues such as lack of relevance of science, the declining numbers of students choosing science subjects in senior school and fewer students pursuing science careers.
They believed teachers would need support and training in order to develop innovative practices such as focussing on enquiry and reasoning, giving students more choice of topics, encouraging discussion and debate, making science more engaging and more relevant to science “in real life” (2006, p. 1). These science educators also believed that teacher training should focus on creating engaging and dynamic teachers in science.

Holbrook (2007) in his ‘endnote’ of his presentation at the ICASE saw teacher educators as being paramount if we were to ‘rethink science,’

It seems that much responsibility for the current state of science education rests with the "trainers of teachers", i.e., the teacher educators. It seems their philosophy of science education is suspect, possibly because teacher educators do not appreciate why science education is part of the curriculum and tend to adopt a view of science education being an isolated and discrete part of education having its own goals (p. 8).

The impact of teachers, their professional development, and classroom environments was taken into consideration when analysing and interpreting the data for the research for this doctoral thesis and teacher input in the form of teacher interviews and discussion forums were included in this study.

(vi) A Study where Students’ Attitudes Became More Positive towards Science as they Progressed through School

This following section describes a study that did not support the trend of declining positive attitude towards science as students progressed through school. It is included in this section as it relates to pedagogy, but it also relates to gender as it took place in girl’s school (this study is also discussed under ‘Gender Issues, Achievement in Science and Ability’ above). In a longitudinal study where students moved from primary into secondary school in New Zealand, involving a group of female students, significantly more students found science attractive in year nine (secondary school) than in year eight (primary school) (Whitten, Tuck & Haigh, 2003). The factors that influenced this trend were noted. This study was quantitative, with additional anecdotal evidence from student diaries supporting the findings of this study. In a number of studies reviewed by the authors of this New Zealand study, boys dominated practical work and classroom interactions in science (Gilbert, 1994; Jones, 1998; Jones, 2000; as cited by Whitten, Tuck and Haigh).
et al. suggested that perhaps teachers of girls-only classes might concentrate on areas and learning styles that appeal to girls in their teaching of science, thus forming a positive teacher-student relationship. The nature of the science teaching at Ascott College where the research study was conducted was worth considering when reviewing the results of the study. The authors mentioned that it was possible that the teachers at Ascott College related to their pupils in a warm encouraging way that led to positive attitudes amongst the students. All units of science at the College included activities to elicit the prior knowledge of the students. There were a variety of activities, including a large number of practical science lessons within each unit. The students in most classes did not copy copious amounts of notes from the board and “teacher talk was limited” (Whitten et al., p. 20). These are teaching practices, which have been highlighted in the previously reviewed research literature to be good classroom practices.

6. Other Factors Relating to Research in this Field

This final section of this literature review is organised under the following subheadings:

a) students’ voice in research;

b) weaknesses in attitudinal and interest research; and

c) gaps in research.

(a) Student Voice in Research

Students are rarely given a voice to present their ideas on subjects that concern them (Murray & Reiss, 2005). An exception is Murray and Reiss’s (2005) study, which presented the findings of a student-led review of the science curriculum in England. According to these authors this review was the first of its kind, in which students designed and implemented a web-based questionnaire study. Approximately half the respondents in this study were “aged 16 or over and were not studying science and just over half those aged 16 or under did not expect to study science post 16”; therefore the findings were from a broad cross-section of students (2005, p. 84). The ROSE study also has sought to give students ‘a voice’ (Jenkins & Pell, 2006). Jenkins and Pell (2006) believed that by listening to the students’ interests, beliefs and responding to their needs, the ‘alienation’ that is felt by some students from their schooling could be reduced, thus addressing other problems.
associated with this alienation. Jenkins and Pell also discussed how giving students the opportunity to take part in decisions about their own education may allow them to see the “complexities and limitations” involved for science educators and help prepare them for their future in society (p. 4). Listening to the voice of the students will be paramount in this doctoral thesis.

\textbf{(b) Weaknesses in Attitudinal and Interest Research}

In addition to lack of clarity with the definition of terms, Ramsden (1998) highlighted other weaknesses in attitudinal research such as:

- poor design of instruments to measure data;
- failure to appropriately address areas of reliability and validity; and
- inappropriate analysis and interpretation of data.

Looking at qualitative research in general, Anfara, Brown and Mangione (2002), stressed the importance of the documentation of all procedures to enhance “internal validity (triangulation)”, the development of ‘themes’, and showing how the data sources relate to the research questions (p. 33). When analysing students’ views, which might constitute a ‘positive’ attitude to science in some areas, Ramsden suggested that “value-judgements” might be involved (1993, p. 132); this highlights the importance of careful analysis and interpretation of data. The importance of reliable instrument design in quantitative research was stressed by Gardner (1995) and he discussed problems associated with this style of research. He described cases of research where the variable that is being measured was not clearly defined and items were grouped together with no common construct. Osborne et al. (2003) discussed when quantitative attitudinal research projects have poor instrument design; it is often unclear exactly what is being measured in the study. For the purpose of the research as part of this doctoral thesis, taking care to avoid these weaknesses was essential. These issues are addressed in Chapter 3.

\textbf{(c) Gaps in Research}

Identifying the gaps in the area relating to the research about to be undertaken is an important process in the early stage of designing a research project. Ramsden (1998) discussed how studies looking at attitudes to science were less frequent in 1998 than they
were 10 to 15 years earlier. Ramsden saw the need to ‘revisit’ ‘attitudes to science’. She saw explanations of why students are “alienated from science” as being one of the main issues facing researchers. She discussed how it would be good if research could take “one step further and provide a sound basis on which to make informed decisions about aspects of classroom practice” (p. 134). Osborne et al. (2003) remarked how there had been a reliance on quantitative studies based on questionnaires in attitudinal research and they stated that relatively few studies had been conducted to look at students’ attitudes to science through the use of “clinical or group interviews” (p.1059). Osborne et al. discussed how qualitative studies relying solely on interview data were very rare, and although they were limited due to their small size and restricted in their generalizability, they produced rich data, which is capable of giving insight into the underlying factors influencing students’ ‘attitudes to science’. They also believed that we needed to look at how attitudes to science are impacting on students choosing science post-16.

Jenkins and Pell (2006) discussed how it is assumed that discovering more about students’ “interest, enthusiasm, dislikes, beliefs and attitudes” will assist developments in curricula to enable students of both sexes to be engaged in school science (p. 3). Although there has been a large amount of research into attitudes and interest in the past, this research has had little impact on “pedagogy or curriculum reform” (Jenkins & Pell, 2006, p. 2). Jenkins and Pell concluded by saying that if student attitudes to, and interest in science, are to be understood more clearly, more complex, sensitive, qualitative and longitudinal studies need to be undertaken to allow the important issues to be identified and “tracked over time” (p.50). Few longitudinal studies had been conducted in attitude research (Ramsden, 1993; Reiss, 2000) and Reiss (2000) discussed how there had been few studies to show what maintains student ‘interest’ in science. There has also been little written about students’ attitudes and beliefs about science in primary school (Andre et al., 1999).

Lindahl (2003, p. 5) discussed how it was difficult to find studies showing the relationship between many of the variables in attitude research and the reasons why there are changes in individual students’ attitudes. She also noted the lack of studies showing the relationship between scientific concept understandings and attitudes towards science (p. 5). Osborne et al. (2003) questioned why there have been so few studies which had sought to
find the students’ views of effective science teaching, even though there is strong evidence to suggest the link between teachers and teaching styles on attitudes towards science and they stressed the urgency for research in this area.

It is very important according to Koballa and Glynn (2007) for researchers to adopt practices that include affective characteristics, such as looking at the constructs, attitude and motivation, particularly in a learning environment where learning is becoming more “constructivistic” as researching only the cognitive areas does not give a full picture of what is happening in the minds of the learners (2007, p. 93). It is important for researchers to devise “theoretical orientations and models” that show the relationship between the constructs, such as attitudes and motivation, and cognition (2007, p. 93).

It appears that school (and tertiary) science seems far removed from the students’ interests and needs of the 21st Century. Tytler (2007a) stressed the urgency for educational reform in science. This highlights the importance of listening to the voices of students to determine what it is that captures the students’ interest and motivates them towards engagement in school science, and leads them to a positive attitude towards the subject.

An overview of the gaps in research highlight the significance and urgency of this research project:

- few longitudinal studies and the significance of these;
- few studies looking at attitudes to science in primary school;
- relatively few qualitative studies, particularly those undertaken over time;
- few studies looking at teaching practices, particularly those that have been identified by students as increasing their interest in science;
- few studies involving clinical or group interviews;
- the need for sensitive, complex, qualitative studies (which could be interpreted as looking at school science issues from the ‘eyes of the students’ and giving students a voice); and
- the urgency to establish the factors that interest students in, and develop a positive attitude towards, science, or in other words finding out what ‘switches the students on’ to science.
Conclusion to Literature Review and Relevance of the Study

This literature review reveals that there is a crisis with school science in Australia and many other countries particularly relating to the decrease in positive attitude as students progress through school and the uptake of science as a career. This is at a time where science and technology play a major role in society as people are looking towards science to address the many problems facing us in the 21st Century associated with global warming and health issues. Not only do we need more people to pursue a science career to address the projected shortages in scientists in the future, but it is essential for the population to be scientifically literate, to be able to critically examine issues relating to science and make informed decisions to address the problems facing us in the future. At this time when research into science education is so essential, the literature reveals that there are many gaps into research in this very important area. One of the key elements that emerged from this literature review is the importance and the urgency of finding out what ‘switches students on’ to science. My goal in this research project is not only to look at how and if students’ attitudes to, and interest in, science change as they move from primary into secondary school but to discover the student-perceived and other factors that lead to a positive experience in science in order to motivate and engage students in science content, sustain their interest and commitment to the subject and enable students to maintain a positive attitude towards science throughout their schooling and increase the numbers of students gaining a ‘personal interest’ in science.

This review of literature relating to the attitudes of school students towards science is comprehensive but not exhaustive. For this doctoral research project most of the major and recent literature has been reviewed in this thesis.

The Following Chapter

The following chapter is an outline of the theoretical framework that underpins my methodology of the research design and methods that were influenced and guided by this review of literature.
CHAPTER THREE

RESEARCH DESIGN AND METHODS

The Sections in this chapter are organised as follows:

1. an introduction to the chapter (for both the quantitative and qualitative components of this study, the research aim, research questions, the research context and its significance);
2. the attitudinal survey (the methodology and methods);
3. the case study (the theoretical stance, methodology, methods, and analysis); and
4. a timeline for the research and its credibility, trustworthiness, transferability, limitations and strengths.

1. Introduction to the Chapter

This chapter looks at the design of this research project. It outlines the methodology and the methods used. The study involved two components:

- An attitudinal survey - which is a quantitative component consisting of an attitudinal questionnaire.
- A case study - which is a qualitative component and the main focus of this research project.

The introduction to this chapter includes the following sections:

a. research aim;
b. overall aim;
c. research questions; and
d. research context and significance.
a. Research Aim

Problem Focussed Research

A researcher must have an idea to stimulate an enquiry and this is a “critical attribute” whether the research is quantitative or qualitative (Wolcott, 1992, p. 7). Wolcott divided the ideas that drive qualitative research into three categories: “theory-driven ideas, concept-driven ideas and reform or problem-focussed ideas” (p. 7). With this research project a problem was identified (students’ attitude to science generally becomes more negative as students go through primary and into secondary school) which initiated the research; the research could therefore be said to be “problem-focussed” or “problem-orientated”. This study was designed to first identify if this ‘problem’ occurred in the sample where the study took place and if so what were the student perceived and other factors that have led to the problem. This project is intended to be the basis for “reform research” or “action research”. The final chapter (Chapter 9) outlines an additional project associated with this study, which was initiated and designed by teachers at the schools where this study was conducted and although it was not set up as a major research project it could be said that it is “action research” as it was set up to address the problem identified in the original project. However the research design of this project is outlined in Chapter 9 and not included in this chapter.

b. Overall Aim

The aim of this research project was to carry out a longitudinal case study to follow a group of 21 students from upper primary school and through into secondary school, to examine the changes in the students’ attitudes to, and interest in, science. The emphasis of the study was to listen to the voice of the students to determine the factors that have influenced these attitudes and interests and have led to motivation and engagement in the classroom. The case study has an interpretivist approach (Neumann, 2000) and is essentially qualitative.

There is also a quantitative component to the study, in the form of an attitudinal survey, administered to a larger sample size. Its purpose was to further inform the case study data.
The use of these mixed methods suggests the study has elements of a pragmatist paradigm (Tashakkori & Teddlie, 1998). The research methodology behind the case study is phenomenology; this approach is reflected in the method, using multiple data sources (e.g., student/teacher interviews, focus groups, classroom observations, journals, student questionnaires, parent surveys and student work samples). It is suggested that by combining multiple data methods the strengths (or weaknesses) of each of these methods will be different and when used in combination will result in better evidence (Johnson & Christensen, 2004, p. 254). These multiple data sources allowed the researcher to understand how the students interpret their world and gave insight into the students' attitudes to, and interest in, science, and also into the factors that led to their motivation and engagement in the classroom. By the use of multiple data methods the researcher gained a deeper glimpse through the eyes of the students into how they perceived science in society and their school science experience over the primary/secondary interface.

c. Research Questions

The research questions that are addressed in this study are:

1. How do students’ attitudes to, and interest in, science change as they move from primary school into high school?
2. What are the factors that affect the changes in attitude and interest towards science?

d. Research Context and Significance

The science education literature reveals a crisis in school science in Australia, and a number of other countries (Tytler, 2007a), relating to a decrease in positive attitude in science as students move from primary school into secondary school (Braund & Driver, 2005; Ferguson & Fraser, 1998; James & Smith 1985; Jarman, 1990; Keogh & Naylor, 2004; Simpson & Oliver, 1985) and as students progress through secondary school (Baird, Gunstone, Penna, Fensham, & White, 1990; Simpson & Oliver, 1990; Yager & Yager, 1985). Negative experiences in school science and decline in students’ positive attitude towards science is reflected in the numbers of students choosing science subjects in senior secondary school (Goodrum et al., 2001). It is also apparent that the numbers of students pursuing science as a career is in decline (Metherell, 2006; Rothapfel, 2004) in Australia. There is an urgency for a study of this nature in a climate where science and technology
play a major role in society and at a time when people are looking to science to address the problems associated with environmental issues, climate change and health issues. At this time when research into these areas is vital, ‘gaps’ have been identified in the science education literature and these have been highlighted in the literature review and have added significance to and provided assistance in the design of this research project (see ‘Gaps in Research’, Chapter 2). Existing literature has also influenced the interpretation of this study and the direction this study has taken. The researcher’s background is in both primary and secondary science teaching and this has led to an appropriate knowledge and understanding of the school environment; skills, which are essential when carrying out a research project such as this.

Please refer to the Introduction (Chapter 1) and Literature Review (Chapter 2) for a discussion of the purpose and relevance of the research, as it is important for the reader to be aware of the major issues surrounding the research in order to understand the main case study methodology and the methods underpinning this research project.

The following section firstly describes the attitudinal survey, and then secondly describes the main methodology and methods of the case study. The components are discussed separately as the attitudinal survey is a study in itself and the case study is the main focus of this research project. However the findings of the attitudinal survey are incorporated into the case study, and the sample survey respondents include participants from the case study, so essentially the attitudinal survey is one of the methods used in the case study.

2. The Attitudinal Survey (Pell & Jarvis, 2001)

The Attitudinal Survey section is divided into the following two subsections:

a. attitudinal survey in 2004 to obtain cross-sectional data; and
b. re-administration of attitudinal survey in 2005 to obtain longitudinal data.

a. Attitudinal Survey in 2004 to Obtain Cross-sectional Data

This sub-section includes information under the following headings:

i. a description of the attitudinal survey;
Chapter Three

i. selection of sample;
ii. administration of questionnaire;
iii. analysis of questionnaire responses; and
iv. input from teachers regarding the findings of the attitudinal survey

(i) Description of the Attitudinal Survey

An attitudinal survey was administered in 2004 to obtain cross-sectional data related to student attitudes as they move from primary school into secondary school (in science in the schools involved). It was also re-administered in 2005 to obtain longitudinal data for the cohort of students moving from year six (2004) to year seven (2005). This component of the study is quantitative and was administered to the classes from which the students in the case study were selected. This questionnaire was applied to a cross section of students (N=264) from years 5 to 10 to determine students’ attitudes towards science across the interface and into the secondary years. The findings of this quantitative study therefore provide contextual data for the case study and a benchmark to allow comparisons of the 21 study participants with this larger sample.

Pell and Jarvis (2001) developed the validated attitudinal questionnaire used in this attitudinal survey (Appendix E). This questionnaire contained 43 items in 3 main scales that consisted of: ‘Being in school’; ‘Science experiments’; and ‘What I really think of science’ (Table 3.1). Further analysis revealed five sub-scales. These were: ‘Liking school’; ‘Independent investigator’; ‘Science enthusiast’; ‘Social context’; and ‘Difficult science’ (Table 3.1). Three of these subscales were combined to create a composite subscale ‘Science interest’ (Table 3.1). These sub-scales allowed the researcher to analyse areas separately; for example: the researcher was able to analyse ‘Independent investigator’ to assess whether the students liked to take more control over their science lessons or if they preferred to let the teacher make all the decisions regarding their practical science. The ‘Social context’ scale allowed the researcher to look at how the students viewed ‘world science’ in contrast to their own school science experience and the ‘Science difficulty’ scale allowed an insight into the students’ perceived difficulty of the subject and how this might change over the primary/secondary interface. One of the reasons why this instrument was chosen was that it included a composite scale relating to interest in science
<table>
<thead>
<tr>
<th>Main Scale</th>
<th>Derived sub-scale</th>
<th>Reliability Cronbach Alpha (cf. Pell &amp; Jarvis, 2001)</th>
<th>n</th>
</tr>
</thead>
<tbody>
<tr>
<td>Being in school 1</td>
<td>Liking school</td>
<td>0.75 (0.71)</td>
<td>258</td>
</tr>
<tr>
<td>Science experiments 2</td>
<td>Independent investigator</td>
<td>0.81 (0.69)</td>
<td>262</td>
</tr>
<tr>
<td>What I really think of science 3</td>
<td>Science enthusiast</td>
<td>0.72 (0.72)</td>
<td>258</td>
</tr>
<tr>
<td>4</td>
<td>Social context</td>
<td>0.67 (0.66)</td>
<td>259</td>
</tr>
<tr>
<td>5</td>
<td>Difficult science</td>
<td>0.61 (0.65)</td>
<td>259</td>
</tr>
<tr>
<td>All 6</td>
<td>Science interest (2+3+4)</td>
<td>0.84 (0.82)</td>
<td>254</td>
</tr>
</tbody>
</table>
in addition to giving an overall indication of each student’s attitude towards the subject. As the research was related to attitude to, and interest in, science, the sub-scales and composite scale, as part of this questionnaire, were thought to be appropriate for this study. A limitation of this questionnaire was that it was essentially designed for use in primary schools in the United Kingdom. However, as it was important to provide an instrument that was easy to use for students in years five and six in primary school, it was felt that it would be suitable for use with both primary and secondary students in Australia with minor changes (see paragraph below). Before completing this attitudinal survey the students in the secondary school were given an explanation as to the simplicity of the design, which was intended to cater for the primary students in the study in addition to the secondary students.

There were minor changes from the Pell and Jarvis (2001) questionnaire. These were: “doing sums”, which was changed to “doing maths”; the word ‘geometry’, which was added to “working with shapes”; “school science clubs are a good idea”, which was changed to, “school science clubs would be a good idea”; and the cartoon runner on each page was deleted as it was included initially to cater for younger children. All other item wording was kept the same.

This instrument had suitable reliability statistics for its various derived subscales and similar or better scale reliabilities were found when the questionnaire was used in this attitudinal study with students from both primary and secondary schools in an Australian setting (see Table 3.1).

(ii) Selection of Sample

The selection of the schools in which this attitudinal survey was administered was determined by the case study. All schools are in NSW and are coeducational. The secondary school (School C in Table 3.2) was selected according to convenience and proximity (Glesne, 1999) and the secondary school determined the two feeder primary schools. The students in the secondary school in this study are mostly from families predominantly in the middle to upper socio-economic range. For the purposes of this associated cross-sectional study nine classes were chosen in the two primary schools (i.e., Schools A and B in Table 3.2) to allow an adequate number of students to participate in the
Table 3.2

<table>
<thead>
<tr>
<th>School</th>
<th>Year</th>
<th>Expected sample size</th>
<th>Actual sample size</th>
<th>Girls</th>
<th>Boys</th>
</tr>
</thead>
<tbody>
<tr>
<td>A (Prim)</td>
<td>5</td>
<td>94</td>
<td>34</td>
<td>21</td>
<td>13</td>
</tr>
<tr>
<td>A (Prim)</td>
<td>6</td>
<td>118</td>
<td>50</td>
<td>23</td>
<td>27</td>
</tr>
<tr>
<td>B (Prim)</td>
<td>5</td>
<td>26</td>
<td>6</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>B (Prim)</td>
<td>6</td>
<td>6</td>
<td>6</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>C (Sec)</td>
<td>7</td>
<td>114</td>
<td>72</td>
<td>47</td>
<td>25</td>
</tr>
<tr>
<td>C (Sec)</td>
<td>8</td>
<td>83</td>
<td>31</td>
<td>17</td>
<td>14</td>
</tr>
<tr>
<td>C (Sec)</td>
<td>9</td>
<td>119</td>
<td>35</td>
<td>18</td>
<td>17</td>
</tr>
<tr>
<td>C (Sec)</td>
<td>10</td>
<td>111</td>
<td>30</td>
<td>19</td>
<td>11</td>
</tr>
<tr>
<td>D (Prim)</td>
<td>6</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Total</td>
<td>671</td>
<td>264</td>
<td>152</td>
<td>112</td>
<td></td>
</tr>
</tbody>
</table>

*Note.* School code: A, B & D = primary; C = secondary; Sec = secondary; Prim = primary
study. All the year five and six classes were chosen at school A and two of the three year five classes were selected at school B to gain some extra year five students (as year five was poorly represented at school A); this equated with a projected sample size of approximately 120 in each of the primary years which included 15 participant students from the case study component of this research project. The students involved in the case study represented year six at school B (in Table 3.2). The student participant students who were part of the case study, from the third feeder primary school (School D) did not take part in this initial survey. The six participant students completed this attitudinal survey at a later date and their results were incorporated into the data when further analysis was undertaken in 2005. Included in the primary classes was an opportunity class (OC) in primary school A, which consisted of children in years five and six with high intellectual ability. The students from this OC were compared to the students in the mixed ability classes in primary schools A and B. It should be noted that some students of high ability at school A, chose not to go into the OC class. The students in the secondary school were graded into classes according to their ability in science and for the purposes of this component of the study the students in the high ability classes were compared with the children from the other classes (see ‘selection procedure’ under case study [section 3d] for a detailed description, of the selection process for the opportunity class, and how the students were ranked into the secondary classes). The curriculum was the same for all classes in the various years and it did not vary according to ranking. In the secondary school, of 21 possible classes 15 were sampled; these were determined by the cooperation of teachers, parents/carers and students.

The eventual sample included all the top classes in years seven to 10 (the students who had been ranked into these highest classes [e.g., 7.1, 8.1, 9.1, 10.1] were considered to be high ability in this study) and 11 of the 17 remaining middle and lower ability classes with the lowest ability classes represented at all year levels except year nine (although one lower ability class was represented). The expected and actual numbers in the final samples are shown in Table 3.2; the actual sample size was determined by the response rate of the ‘parental/carer approval to participate forms, which were required by the Southern Cross University Human Research Ethics Committee (HREC). In total 671 consent forms were distributed to parents or carers of the students and 264 forms were returned (39% response rate). In all, 13 secondary classes were represented in the sample, with students from at
least three classes at each of the year levels. This overall sample of 96 primary and 168 secondary students with 112 boys (42.4%) and 152 girls (57.6%), across nine primary and 11 secondary classes, it was hoped, would produce sufficient variation in the context in which science learning was occurring and hence improve the probability of understanding how and why students change their attitudes and interests in science during these years. Three of the teachers at the secondary school who were teaching year seven classes in addition to other junior science classes in years eight to ten, in 2004, were relatively inexperienced teachers; in that they had been teaching for three years or less. All principals, teachers and other appropriate persons were informed as to the nature of the study and the results from this attitudinal survey were presented at all schools.

(iii) Administration of Questionnaire

The researcher administered this survey during midyear, 2004. It was felt that by administering the survey in the middle of the year it would allow the students to have fully settled into their various classes (particularly those who were in year seven, secondary school). The questionnaire is designed to be self explanatory, however, the nature of the study and how this survey was to be used was explained to the students, the students were shown the sample question and asked to ensure that all sections of the survey were completed and when administering the survey to secondary students it was emphasized that the questions are very basic as it is designed to make it easy for primary students to complete.

(iv) Analysis of Questionnaire Responses

Analysis of the quantitative responses to the survey was completed using the Statistical Package for the Social Sciences (SPSS). As all items were worded to avoid negative phraseology, which Pell and Jarvis (2001) argued would make these items more accessible to young children, all items were recoded (5=1, 4=2 etc.) in order that high interest could be aligned with high scores, and the low interest aligned with low scores. The means for the individual items across the primary and secondary divisions, were compared by determining the distribution of responses using a chi-square test. Scores for the derived sub-scales of ‘Liking school’ (10 items; maximum score 50), ‘Independent investigator’ (9 items; max 27), ‘Science enthusiast’ (8 items; max 24), ‘Social context’ (8 items; max 24)
and 'Difficult science' (5 items; max 15), and the composite scale of ‘Science interest’ (25
items comprising the sub-scales of ‘Independent investigator’, ‘Science enthusiast’ and
‘Social context’; max 75) were calculated. Means for these derived and composite scales
were compared across primary and secondary cohorts (independent t-tests) and across
individual school years (ANOVA).

Some studies have indicated that there are gender differences in children’s attitudes
towards science (Martin et al., 2000), particularly during the primary/secondary interface
years (Baird, Gunstone, Penna, Fensham & White, 1990; Ferguson & Fraser, 1998;
Simpson & Oliver, 1985), although it is noted that Whitten, Tuck, and Haigh’s (2003)
study of New Zealand girls as they moved from primary school into a girls’ secondary
school did not find a decline in attitude towards science over this period. Also Hasan
(1985) has shown that there is a relationship between intellectual ability and attitude
towards science. Consequently the questionnaire sub-scale scores were analysed to
determine whether any differences were revealed between boys and girls and students of
different ability. The students in the opportunity class at the primary level, and in the
classes graded for the highest ability students at the secondary level, were coded as ‘high
ability’ students in this survey. All other students were coded ‘mixed ability’ (or other)
(please refer to section 3d ‘Selection Procedure’ in this chapter for further information
regarding grading for year seven students and selection procedures for the opportunity
class in primary school).

As stated the Pupils’ Attitudes to Science instrument, used in this study, contains five
scales. This questionnaire also includes two open-ended items, namely “a good thing about
science” and “a bad thing about science”. The responses to these two questions were coded
into categories. The code titles used words that reflected the wording used by the students.
The total number of responses was determined and hence the percentage frequency of
responses for each category was calculated. The findings from this survey issued in 2004
are included in the results in Chapter 4.

(v) Input from Teachers Regarding the Findings of the Attitudinal Survey

The researcher presented the findings from this attitudinal survey in December 2004, to
both the primary teachers and the secondary teachers from the representative schools. The
presentation involved the use of tables and graphs to illustrate these findings. The teachers’ responses were audio taped and transcribed and were used when interpreting the data to assist in looking at strategies to help maintain students’ interest in science across the primary/secondary interface.

**b. Re-administration of Attitudinal Survey in 2005 to Non-Case Study Year Seven Participants to Obtain Longitudinal Data**

This sub-section includes the description of the attitudinal survey, the selection of sample and the analysis of responses of the 2004 Attitudinal Survey.

**(i) Description of the Attitudinal Survey**

The questionnaire used in this attitudinal survey (Pell & Jarvis, 2001) was re-administered in 2005 to year seven students (N=49) including all (20) remaining case study participant students at school C (one student left school C early in year seven and did not continue in the study). Although this questionnaire was re-administered to largely the same cohort of students as those in year six in 2004, it should be noted that the respondents in this 2005 attitudinal survey had not necessarily completed the survey in 2004 as it was an anonymous survey which was administered to only a sample of year six students in 2004 (N=56) (Table 3.2). It is also possible that the students in the 2005 study may have attended feeder primary schools that were not involved in the attitudinal survey in 2004.

**(ii) Selection of Sample**

In addition to the 20 students in the case study, 154 consent forms were distributed to parents or carers of the non-participant students in year seven (as required by the Southern Cross University Human Research Ethics Committee) and 32 parents/carers responded (20% response rate, which meant it was only a small sample of year seven students). All year seven classes were represented in the sample. This overall sample consists of 52 students with 24 boys (46%) and 28 girls (54%) (Table 3.3).

---

1 It needs to be noted that the attitudinal questionnaire was administered in 4th term 2005, whereas it was administered at the end of 2nd term in 2004.
Table 3.3

*Sample Characteristics for Attitudinal Survey Administered in 2005 (Number of Students by Gender)*

<table>
<thead>
<tr>
<th>School</th>
<th>Year</th>
<th>Expected sample size</th>
<th>Actual sample size</th>
<th>Girls</th>
<th>Boys</th>
</tr>
</thead>
<tbody>
<tr>
<td>C (Secondary)</td>
<td>7</td>
<td>154</td>
<td>52</td>
<td>28</td>
<td>24</td>
</tr>
</tbody>
</table>

*Note.* School code: C = secondary participant school in 2004 attitudinal survey and 2005 case study
(iii) Analysis of Responses

The results were analysed using SPSS. In order to ascertain what change, if any, occurred, the means of the participant and non-participant students were compared across the primary/secondary interface using independent t-tests in the following categories: ‘Independent investigator’; ‘Science enthusiast’; ‘Social context’; ‘Science interest’; and ‘Science difficulty’. A comparison between the attitudes of the participant students in year seven (2005) and those of the non-participant students in year seven (2005) was also possible by comparing the means in the categories outlined above using independent t-tests. The questionnaire sub-scale scores were analysed to see if any differences were revealed between boys and girls and students of different abilities. In order to look at any student ability differences in the sub-scales, the students’ scores in the two high ability classes were compared with those of the students of the mixed ability classes (see ‘selection procedure’ under case study [section 3d] for a detailed description of how the students were ranked into the secondary classes). The researcher administered the questionnaire in third term 2005. The findings from this longitudinal application of the attitudinal survey administered in 2005 were included with the results in Chapter 5 as they further informed the interpretation of the case study data. Statistical differences in gender or ability amongst the 20 study participant students, was not determined, as the sample size was too small to gain significant results (boys $N=10$, girls $N=10$).

3. The Case Study

This section is divided under the following headings:

a. the theoretical framework of the case study: symbolic interactionism;

b. what is a case study?;

c. the phenomenological approach;

d. the selection procedure;

e. data collection;

f. repeating aspects of data collection; and

g. qualitative analysis of the case study: how was it done?
Chapter Three

a. The Theoretical Framework of the Case Study: Symbolic Interactionism

The theoretical framework that underpins the main methodology behind the case study (Crotty, 1998) is symbolic interactionism. Coming from a symbolic interactionism theoretical perspective the researcher is aware that people create their own world and interpret their world in their own unique way (Bogdan & Bicklen, 1998). The basis of this approach is that the interpretation of a person’s surroundings impacts on how they experience their world and how they behave in it. To be able to understand the behaviour of the participants the researcher must understand the “processes” that “manufactured” the behaviour (p. 25). How the students define their world will determine how they behave in it (Bogdan & Bicklen). When looking at school science, how a student defines their science determines his or her experience of, or actions towards, the subject. Students’ definitions of science may change according to their experiences. A student may read and interpret the signals and symbols that they come into contact with in their classroom environment in a very different way to how the classroom teacher interprets the same classroom environment; for example, a student may interpret the copying of notes from the blackboard as being a tedious time wasting exercise, whereas a teacher may see it as a way of increasing the students’ scientific knowledge and reinforcing scientific ideas. Sometimes students may develop common or “shared definitions” with other students and the way they define their environment can change according to their experiences with their peers (Bogdan & Bicklen, p. 25). A child’s interpretation of his or herself may be influenced by the interaction of their teacher and other students, and the gestures and actions that these people direct towards that child. In order to understand how each student interprets, defines, and reads signals and symbols relating to their environment, the researcher has used multi-methods of data collection to enter into the defining processes (Bogdan & Biklen, 1982). These methods include participant observation, individual interviews, focus groups, surveys, and teacher interviews. The researcher has endeavoured to listen to the voice of the student, to take into consideration the individual differences of the students, and has observed the interaction between students and teachers, students with each other, and students with their surroundings. By the use of these various methods the researcher has attempted to interpret what the students are saying from their own unique perspective taking each of the student’s views seriously (Crotty, 1998). The principal
methodology behind the case study is phenomenology, which is compatible with the symbolic interaction theoretical underpinnings of this thesis.

b. What is a Case Study?

Case studies can provide unique glimpses of people in real life situations (Cohen, Manion & Morrison, 2000). Stake’s (n.d.) footnote (as cited in Bassey, 1999, p. 27) gives an insight into the complexity of case studies: “It is important for us to recognize that others will not use the words or the methods as we do”. There is much variability in the literature as to the definition of the term ‘case study’ (Bassey, 1999). For the purposes of this thesis a case study is interpreted to be research of a particular setting (Merriam, 1998), such as a class, a school or a community, and an observational case study is where the main techniques for gathering data are participant observation, interviews, and review of documents within a setting (Bogdan & Bicklen, 1998). As this research project has focussed on one secondary school and its feeder primary schools and has followed a small number of students, using data-gathering techniques including those mentioned above, it could be described as an observational case study.

A ‘Case study’ need not necessarily be seen as a methodology. Rather is signifies that a specific ‘case’ has been investigated. Here that case was 20 students moving from a primary school science setting to a secondary school science setting. Listening to the voice of students and interpreting the world from each participant’s point of view, has been an integral part of this case study. Therefore the chosen methodology is phenomenology used in this case study, to enable a deep understanding of how each individual participant views their world around them, particularly the factors that affect the participant’s changes in attitude to, and interest in, science, (see research question 2, Chapter 3).

c. The Phenomenological Approach

It is difficult for us to fully understand how children develop, as there are so many factors that influence this development. Each child has developed both mentally and physically at a different rate and all have had unique life experiences that have influenced their consciousness. We can make observations of how well a child performs at a particular
task to gain understanding of aspects of his or her physical or mental capabilities, but it does not tell us about the child’s consciousness. To understand a child’s behaviour we need to understand the child’s beliefs. However it is a mistake to explain a child’s beliefs as being caused by factors outside his or her consciousness. Considering factors that affect consciousness is part of the phenomenological approach (Curtis & Mays, 1978, pp. ix-xii).

Edmund Husserl was considered to be one of the founders of phenomenology (Moran, 2000). Husserl was concerned with the way people relate to their world and peoples’ consciousness (Greene, 1986). Husserl questioned assumptions that people ‘take for granted’ in their ‘day to day’ living (Cohen, Manion & Morrison, 2000, p. 23). Greene described how phenomenologists such as Husserl, Jean-Paul Sartre, Maurice Merleau-Ponty and Alfted Schutz, although having varying viewpoints, all shared an interest in the existence of the individual, “intersubjectivity, and human freedom”, and all were committed to individual consciousness (p.494). Sartre and Merleau-Ponty saw phenomenology as “capturing life as it is lived” (Moran, 2000 p.5).

To illustrate the phenomenological viewpoint, Bogdan and Biklen (1998) gave an example of a policeperson’s comments at the scene of an accident where each witness had a different interpretation of what happened, “It all depends on where you are sitting how things look to you” (p.23). If we recognize that interpretation is important and there are many different ways of interpreting any given situation, we can also see that our own way of seeing the world may get in the way of what there is to learn about a situation. The researcher during this study has sought to interpret the situation from the students’ view and how the world presents itself to the student (Bogdan & Bicklen, 1998; Greene, 1986) particularly the world of the science classroom or how the students’ world relates to science in society. The researcher has been aware of the “realities” or different worlds that children encounter such as home, social life, school playground and the classroom (Greene, 1986 p.496). Each of these realities requires a different “mode of cognition” and in the crossing from one reality into another there is different meaning for each situation (Greene, 1986 p.496). The researcher is aware of the realities of the “science classroom” and has sought to understand how students “make sense” of this quite different world (Aikenhead, 1996 p.3). The phenomenological approach has been reflected in the methods of this case study, with multiple data sources used to assist the researcher to understand
how the students interpret their world, including the impact of each student's parents, peers and teacher and how these factors might impact on their attitudes to, interest in, and the motivation and engagement within the classroom. The researcher endeavoured to see through the eyes of the students to discover what 'switches them on' to science. The many factors that appeared to lead to interest in, motivation towards, and engagement in, science, were examined and possible explanations of how and why the individual students formed their particular attitudes towards the subject were sought. The researcher also attempted to determine factors that 'switch students off' science and lead to disinterest, disaffection, lack of motivation, and a negative attitude towards the subject.

**d. The Selection Procedure**

The participants were selected in order to discover variations that might exist across two main groups of students (Strauss & Corbin, 1997). As studies have indicated that there are gender differences in children's attitudes towards science, particularly during the changes as they move from primary into secondary school (Ferguson & Fraser, 1998; Simpson & Oliver, 1985), relatively equal numbers of boys and girls were selected; however it is noted that Whitten, Tuck, and Haigh's (2003) study of New Zealand girls as they moved from primary school into a girls' secondary school did not find a decline in attitude towards science after the girls entered school: this has been taken into consideration as the data was interpreted. Selection of participants was also according to intellectual ability as Hasan (1985) has shown that there is a relationship between ability and attitude towards science. All schools were in NSW and were coeducational. Selection of the secondary school was according to convenience and proximity (Glesne, 1999). The students in the secondary school in this study were mostly from families predominantly in the middle to upper socio-economic range. The secondary school determined the three feeder primary schools. By choosing a number of primary schools and classes, it was hoped that variations existed in the style of science being presented. Any variation of science presentation was examined to see if it had any influence on the students' attitudes to, and interest in, science. The classes were chosen as a result of teachers volunteering to participate in the study. Student ability was determined on the basis of class and recommendation from teachers. The teacher of a year five/six opportunity class designed for intellectually gifted students (at primary school A) was keen for his year six students to take part in the research project. Students throughout the region were selected for this opportunity class, based on the results of an
‘Opportunity Class Placement Test’, which was designed by the NSW Department of Education and Training (DET). This test, which relates to “reading, mathematics and general ability”, is conducted in late July or early August each year with students in year four NSW who choose to apply for year five opportunity class entry (DET, 2007). It should be noted that some students of high ability in the region who were eligible to go into the opportunity class, chose to remain in the mixed ability classes. Eight students were selected from the opportunity class (four males; four females) for this research project and 13 students were chosen from the other mixed ability classes (six males; seven females). The eight students from the opportunity class were compared to the 13 students from the mixed ability classes in year six. Hence the study involved 21 students who were enrolled in year six during 2004; this was considered to be a manageable number. It was anticipated that at least ten to twelve students would remain in the study for the full duration. However 20 students remained in the study in 2005 as only one student left the secondary school early in 2005.

The classes chosen in the secondary school were those where the participant students were assigned on entering year seven. The ranking procedure for year seven was quite complex. The students sat for two tests while in year six 2004; a literacy and a numeracy test designed by the secondary school. The high school in consultation with the primary schools, ranked the students into their year seven classes using primarily two sources of information: information from the test (discussed above), and the results of the 2003 New South Wales Department of Education and Training Basic Skills Test in literacy and numeracy (undertaken by all students in NSW in year five). They also considered learning styles of the groups of students and peer interaction. The students were placed into classes graded from one to six with the top two classes (1 and 2) equal high ability classes. All of these classes (from one to six) followed the same curriculum. The classes were given pseudonyms to increase anonymity (Appendix H). It needs to be noted that students from both the Opportunity Class in year six, and the students in year seven, were streamed largely according to their ability in literacy and numeracy and not according to their science ability. Some students were moved into different classes after completing their half yearly examinations in 2004 and again this was based primarily on their ability in literacy and numeracy, although the fact that some of these students may have performed poorly in their half yearly exams for reasons other than ability, needs to be taken into account when
looking at the results relating to ability in this case study (and also in the attitudinal surveys in 2004 and 2005). The 20 participant students were distributed throughout the year seven classes, and there was at least one student in each of the six classes. All eight students from the opportunity class were placed in the high ability classes in year seven and four students from the mixed ability classes in primary school were also placed in the two high ability secondary classes. These four students who were formerly considered mixed ability students, were included in the high ability group after year seven, (one male; three females), resulting in twelve high ability students, (five males; seven females) and eight mixed ability students, (five males; three females) in secondary school.

**e. Data Collection**

Multiple data sources helped describe the case study context in detail. The data were collected once during one time period in the second half of years 6 and 7. This case study involves two components: firstly, determining whether the attitudes towards and interest in science change for this group of students across years 6 and 7 and secondly, attempting to understand why these students may have changed their views. To determine this sample group’s attitudes towards, and interest in, science, during this period Pell and Jarvis’ (2001) attitudinal survey was administered as outlined above (section a). The data from this attitudinal survey is used to assist in describing this study’s context and interpreting other data related to individual sample students.

The case study has continued following those participant students who agreed to continue with this research into years eight, nine and ten. However this doctoral thesis only follows these students through from years six into year seven.

To determine how these students perceived their school science environment and how their attitudes to, and interest in, science, changed when they moved from primary into secondary school and the factors that affected any changes in attitude and interest, towards science, or that encouraged their motivation and engagement in their science classes, a variety of data collection methods were used; these are outlined below under:

i. semi-structured interviews with student participants;

ii. focus groups;
iii. non-participant observations;
iv. student journal and student science work;
v. written responses (short survey);
vi. teacher interview;
vii. parent survey; and
viii. anecdotal and evidence researcher diary.

(i) Semi-Structured Interviews with Student Participants

The researcher conducted individual semi-structured interviews with each student participant. These semi-structured interviews are midway between formal structured interviews and informal, unstructured interviews (Flick, 1998); they combined Patton’s (1990) “interview guide approach” with his “standardized open-ended approach” to interviewing (p. 288). Patton’s ‘standardized open-ended interview’ is where questions are set beforehand and all the questions have the same wording, in the same order, for each interviewee. Patton’s ‘interview guide approach’ is where the interviewer outlines the topics and issues that are to be covered with the interviewee before the interview takes place and the interviewer decides the wording and sequence of the questions used in the interview, as the interview proceeds. The questions for these semi-structured interviews with student participants were determined in advanced (Appendix A) and all student participants were asked the same questions, as in Pattons’ ‘standardized open-ended interview’. However, there was more flexibility than a ‘standardized open-ended interview’ and the questions used were not restricted to the prepared questions as the researcher probed and determined when it was appropriate to “explore certain subjects in greater depth or even to undertake new areas of enquiry” (Patton, p. 287) in order to give the researcher a deeper understanding of the students’ opinions and views about science generally. As in Patton’s ‘interview guide approach’ these semi-structured interviews often resulted in rich conversation with the students.

The interview questions were formulated by combining examples used in the science education literature (Gardner, 1985; Jo & Song, 2003; Reiss, 2000; Rennie, Hackling & Goodrum, 1999 [as cited in Goodrum, Hackling & Rennie, 2001]; Murphy & Beggs, 2003). The age of the student participant was taken into consideration by the researcher.
who has a background in child development, to ensure that each question would be appropriate for the understanding of each student participant. The interviews were approximately 10 - 15 minutes duration. Each participant was interviewed twice, once during each data collection period in years 6 and 7. These interviews were audio-taped and transcribed. Copies of all transcripts have been retained for future viewing or further analysis. Conducting individual interviews allowed the researcher to get to know the general interests of each student, attempt to assess whether the student was interested in science, to determine aspects of science that the student liked or disliked, or what ‘switched them on’ to science, and assisted the interviewer in gaining a glimpse of how each student viewed his or her world particularly in relation to school science and science in society.

(ii) Focus Groups

In addition to the interviews there were same gender ‘focus groups’ conducted by the researcher that consisted of the student participants and a number of other selected students (Hoppe, Wells, Morrison, Gillmore, & Wilsdon, 1995, p.106). Focus groups were chosen as younger children are thought to feel comfortable and less inhibited in a group of children of the same sex (Greenbaum, cited in Hoppe et al., 1995). The ideas and thoughts of the additional students allowed students to compare experiences and gave them the opportunity to react to and add to each other’s responses. Evidence suggests that focus groups may give participants a feeling of confidence as a result of the ‘safety in numbers’ aspect allowing them to answer questions in perhaps more detail than they would in an individual interview. The fact that the students already knew each other also appeared to give them more confidence to be able to express feelings that they may not have felt comfortable in expressing in the individual interviews (Hoppe et al., 1985).

These focus groups were conducted in order to involve each participant student once during each data collection period. The duration of these focus groups was approximately

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2 To create a relaxed atmosphere in the focus groups where the students felt comfortable and to initiate discussion, simple science activities were organised. These included: in year six, making slime, and observation of an egg pushing into a bottle as a result of pressure difference; and in year seven, observation of a water pressure bottle rocket.
thirty to forty minutes. Sample questions were prepared beforehand (Appendix B) to guide
the conversation and to allow each focus group to cover the same questions. The sample
questions were similar to those asked in the individual interviews based on questions found
in the science education literature (Gardner, 1985; Jo & Song, 2003; Murphy & Beggs,
2003; Reiss, 2000; Rennie, Hackling & Goodrum, 1999 [as cited in Goodrum, Hackling &
Rennie, 2001]). These focus groups were conducted as a semi-structured style of interview
where the interviewer initially asked a set of questions but was able to probe and extend
the discussion to gain insight into the views and opinions of these students towards science
in school and science generally with discussion sometimes occurring outside the area of
enquiry (Patton, 1990). All focus groups were audio-taped and transcribed and the tapes
and transcripts were retained for future use. The focus groups in addition to the individual
interviews allowed the researcher to view the student in a relaxed setting with peers,
perhaps gaining a different view of each student, as he or she may have felt more confident
to express their opinions and ideas or emotions towards the subject with their peers
alongside them. It is also essential to be aware that students may have been guarded against
expressing their true opinions if those opinions differed from that of their peers and this
was taken into account when the data was analysed; therefore it was important to also
allow the students to express their ideas in private during the individual interviews. The
addition of the focus group data assisted in increasing cross-validation of data sources as it
enabled the researcher to look for commonalities and differences between the interview,
focus group data and other data (Anfara, Brown & Mangione, 2002).

(iii) Non-Participant Observations

To give the researcher a ‘firsthand’ view of what is happening in the classroom non-
participant observations were conducted (Merriam, 1998). The researcher observed teacher
and student actions and listened to teacher/student utterances that related to science, and
recorded those considered relevant to the study (Reiss, 2000). The researcher looked at the
non-verbal communication of the student participants during the science lessons and
recorded any communication that was relevant. The observations in addition to the other
data sources assisted the researcher in determining aspects of science lessons that “engaged
the children” (Osborne, Simon & Collins, 2003, p.1074) and any aspects of science that
students found less interesting and challenging. Observations were conducted in order to
assist in the ‘cross validation’ of data sources (Anfara et al., 2002), for example, where students stated in interviews and surveys that they were interested in practical aspects of science, it was helpful when analysing the data to assess if the students appeared engaged and motivated during practical science lessons. Observations of approximately two lessons, involving each student participant were conducted during both data collection periods. As noise levels were high in the classroom, particularly during practical lessons, it was not always possible to record a large number of the student utterances relating to science. Some of these students’ utterances relating to specific topics are included throughout chapters five and seven in their relevant sections as part of the discussion and are not specifically highlighted as comments made during student observations. Some student utterances during observations are also included in the student narratives in appendix 1.

The researcher endeavoured to create as little disruption as possible to the classes by sitting at the back of the room and making notes in a field book during these observations (Reiss, 2000). The use of video cameras, although having the ability to produce rich data in the classroom, may have influenced the behaviour of the students (Reiss, 2000) and hence ethics approval for this activity was not sought. The ethics guidelines for this research project required a note to be issued to each non-participant student in the classroom to ensure that data from these students were not included in the study. Ethics approval or parental consent for the use of audiotape recorders during these observations was not sought, as it would have been difficult to gain quality of sound during these sessions. These non-participant observations were helpful in determining, how the students reacted to the science lesson, what emotions they displayed, how motivated they appeared towards the activities and content, if they appeared to display ‘situational interest’ (Hidi, 1990, p. 551), if they exhibited engagement towards the “peripheral things” or “content” (Pugh, 2004, p. 194) or were “disaffected” in the classroom (Skinner & Belmont, 1993, p.572), and what sort of attitude they appeared to display, in the science classroom.

(iv) Student Journal and Student Science Work

A journal was issued to each student in the study to encourage the recording of individual students’ attitudes towards, and interest in, science. Students were asked to
record any feelings about science, including poems or drawings. It was hoped that these journal entries would give an extra perspective on the students’ views and opinions of science. The journals entries of the students who completed them, were collected for observation at the end of year six, but unfortunately no journal entries were made in year seven. The journals were returned to the students after analysis and copies were taken with written permission from the students (Wellington, 2000). The students’ schoolwork was analysed such as science workbooks and assignments, to gain an insight into the individual students’ understanding of, and commitment towards science. These samples were analysed during year six and seven, mostly during third term. The journal (where completed) gave insight into how these students perceived their science experience. The examination of work samples provided additional data to compare with the classroom observations data, in the attempt to assess the students’ level of engagement in the activities. Comments in journals, and the quality of the students’ work samples, were described in the student narratives (Appendix I). Discussion relating to the journals and work samples are also included in the results and discussion (Chapters 5 and 7).

(v) Written Response (Short Survey)

Each student was asked to respond to questions in a written response during both data collection periods, in years 6 and 7. The five simple questions were compiled for this short survey (Appendix D) by adapting examples from the science education literature (Jo & Song, 2003; Rennie, Hackling & Goodrum, 1999 [as cited in Goodrum, Hackling & Rennie, 2000]). This survey was administered to the students to give an extra perspective in addition to the other data collection methods, to increase ‘cross-validation’ of data sources (Anfara et al., 2002). This written response also assisted in gaining an overall picture of the students’ attitudes to, and interest in, the subject, and it gave the students the opportunity to express any ideas in writing that they might find difficult to verbalise during an interview or focus group, hence giving another view of the students’ perception of their science experience.

(vi) Teacher Interviews

It is evident from the research literature that teachers and pedagogy in general can impact on students’ attitudes, interest, motivation, and engagement (See Figure 2.1,
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Chapter 2). In addition to the classroom environment and teaching practices implemented by each teacher, how the teacher relates to each student and the perception the teacher has regarding that student’s behaviour or performance in science, might also impact on how that student responds to science. Therefore it was important to interview the teacher in addition to observing the interactions between the teacher and the student participants in the classroom, to gain a deeper understanding of factors impacting on each student’s attitudes to, and interest in, science. The “interview guide approach” was used for the teacher interviews (Patton, 1990, p. 288). During interviews with the teachers of the participant students, the researcher outlined the topics and issues to be covered and decided on the sequence and wording of the questions as the interview progressed (Patton). The teachers of each participant student were asked to describe how they perceived their students’ attitude to, and interest in, science. They were also asked to discuss the students’ ability in, and performance during, science assessment. This style of interview allowed flexibility and sometimes led to discussions in different areas to those initially intended which gave insight and provided a picture of the student participant from their teacher’s perspective (Patton). These interviews were audio taped and transcribed and copies of all transcripts have been maintained for future review if necessary.

(vii) Parent Survey

Family support or parental attitude is seen as one of the factors that influence, attitude, interest, motivation, and student engagement (See Fig. 2.1, Chapter 2) and how parents perceive the importance of science might influence the encouragement that is given to their children in the subject (Andre, Whigham, Hendrickson & Chambers, 1999): therefore it was important to gain some understanding of the parents’ attitude towards science. A parental survey was conducted where parents were asked to write a response to four questions (Appendix C). The questions inquired about the parents’ own experiences with school science, if they saw the relevance of science being compulsory throughout both primary school and junior high school, and what type of science they would like to see presented in schools. The researcher was interested in determining the parents’ feelings, opinions and attitudes towards science and to investigate if there was evidence of any relationship between each parent’s attitudes to science, with those of their child. The questions were determined using questions in Reiss (2000, p. 57) as a guide. Students’
names were required on the form but as there was no requirement for the parents’ names or sex (this was perhaps an oversight), it was difficult to determine if the response had been completed by the students’ mother or by their father.

(viii) Anecdotal Evidence and Researcher Diary

During the data collection period, anecdotal evidence was collected while informally chatting with students and teachers. Although this data was informal, it assisted when writing reflective comments or when the narratives for each student were written to gain an overall picture of the students and their school environment. A researcher diary was kept to record reflections, personal reactions and feelings during the observations, interviews and focus groups (Flick, 1998). The diary was carried with the researcher at all times; as thoughts or anecdotal evidence emerged about the research, they were recorded immediately (Glesne & Peshkin, 1992).

f. Repeating Aspects of the Data Collection

By repeating the individual interviews, focus groups, classroom observations, viewing bookwork, teacher interviews, student surveys, and attitudinal surveys in year seven the researcher was able to obtain insight into how the students’ attitudes to, and interest in, science had changed as they moved from primary into secondary and with careful observation and analysis of data, to attempt to determine why there were any changes in attitude to, and interest in, science.

g. Qualitative Data Analysis of the Case Study: How was it done?

The data was analysed according to the following procedure:

- the audiotapes of all focus groups, student and teacher interviews, and teacher responses were transcribed. The transcripts were analysed and a summary of responses for each student was compiled in a table with appropriate headings for the various data sources to “bring meaning, structure and order to data” (Anfara, 2002, p.31) at the end of each data collection period;
- data from the observations, written responses, attitudinal surveys, parent surveys, bookwork, student journals and researcher diary, were also included in each
student’s summary table. These tables assisted with the ‘cross-validation’ of data from each data source (Anfara et al., 2002);

- in addition to the individual tables for each student, a combined response was compiled to link the students’ ideas together (Anfara et al., 2002). These tables were grouped according to factors including sex and ability and consisted of data from student interviews, focus groups, written responses and attitudinal surveys (Appendix F provides an example);

- from these combined responses, a summary table of common responses was compiled dividing the comments into factors such as sex, ability, school year and class group, to illustrate underlying patterns, and commonalities and differences across the year groups, ability levels and sexes (an example is shown in Appendix G).

- narratives were compiled to describe each school, class and teaching style, represented in the study (Appendix H);

- individual narratives were compiled for both 2004 and 2005, for each student, using data from the student’s tables (Appendix I). The narratives assisted in providing a story of each student participant’s general interests and attitudes to, interest in, motivation towards, science, and what led that student to engagement with the science activities. They were also compiled in order to give the researcher insight into how these individual students perceived their school science experience. The commonalities and differences between students that emerged from the narratives were carefully analysed (Anfara, et al., 2002, p.31; Glesne & Peshkin, 1992);

- tables were compiled to look at various aspects of the case study, such as subject preference, career choice, parents’ survey responses, science topics and difficult aspects of science (See Chapter 5).

- the findings from all data for the case study were written up at the end of both data collection periods (2004 and 2005) taking care to address the research questions:

1. How do children’s attitudes to, and interest in, science change over the primary/secondary interface?

2. What are the factors that affect the changes in attitude and interest towards science?

The findings from this study were compared to those in the science education literature.

This section is organised under the following headings:

- a. a timeline of the research;
- b. increasing credibility, trustworthiness and transferability;
- c. limitations of the case study; and
- d. strengths of the research.

**a. A Timeline of the Research**

An ethics proposal was presented to the ethics committee both of Southern Cross University (SCU) and the NSW Department of Education and Training (DET), in August/September, 2003. The data collecting took place in 2004, and in 2005. The data were analysed during and after each data collection period and the research was written up in the subsequent twelve months after the final data collection period. The cross-sectional attitudinal survey (Pell & Jarvis, 2001) was administered in May 2004 and analysed in June 2004, while the longitudinal application of the survey occurred in late 2005 (Table 3.4).

**b. Increasing Credibility, Trustworthiness and Transferability**

In keeping with the phenomenological methodology over this time period, the researcher endeavoured to develop a sense of trust between her and the participants. The length of time in the field assisted the researcher in being able to follow up impressions and intuitions (Anfara et al., 2002; Cresswell [as cited in Glesne, 1999]). To ensure the statements of the participants were represented from their own perspective and point of view (Taylor & Bogdan, 1998), copies of the transcripts were given to the schools for approval from relevant participants (Glesne & Peshkin, 1992; Anfara et al., 2002).

The data were inspected closely during the early phases of the study and the information arising out of these data provided a base for the study and interpretation of data (Strauss & Corbin, 1997), according to the symbolic interactionism theoretical perspective,
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Table 3.4

**Summaries of the Data Sources and Collection Periods**

<table>
<thead>
<tr>
<th>Data source</th>
<th>School Year</th>
<th>Data collection period</th>
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<tbody>
<tr>
<td>Attitudinal Survey</td>
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<td>Year seven</td>
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<td>Semi-structured interviews</td>
<td>Year six</td>
<td>2&lt;sup&gt;nd&lt;/sup&gt;, 3&lt;sup&gt;rd&lt;/sup&gt; and 4&lt;sup&gt;th&lt;/sup&gt; terms, 2004, 3&lt;sup&gt;rd&lt;/sup&gt; term, 2005</td>
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<td>Year seven</td>
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<td>Year six</td>
<td>2&lt;sup&gt;nd&lt;/sup&gt;, 3&lt;sup&gt;rd&lt;/sup&gt; and 4&lt;sup&gt;th&lt;/sup&gt; terms, 2004, 3&lt;sup&gt;rd&lt;/sup&gt; and 4&lt;sup&gt;th&lt;/sup&gt; terms, 2005</td>
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<tr>
<td></td>
<td>Year seven</td>
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<td>Year six</td>
<td>2&lt;sup&gt;nd&lt;/sup&gt;, 3&lt;sup&gt;rd&lt;/sup&gt; and 4&lt;sup&gt;th&lt;/sup&gt; terms, 2004, 2&lt;sup&gt;nd&lt;/sup&gt;, 3&lt;sup&gt;rd&lt;/sup&gt; and 4&lt;sup&gt;th&lt;/sup&gt; terms, 2005</td>
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<td>Year six</td>
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<td>Year seven</td>
<td></td>
</tr>
<tr>
<td>Observations of students’ diaries</td>
<td>Year six</td>
<td>2&lt;sup&gt;nd&lt;/sup&gt;, 3&lt;sup&gt;rd&lt;/sup&gt; and 4&lt;sup&gt;th&lt;/sup&gt; terms 2004</td>
</tr>
<tr>
<td></td>
<td>Year seven</td>
<td></td>
</tr>
<tr>
<td>Written responses (short survey)</td>
<td>Year six</td>
<td>2&lt;sup&gt;nd&lt;/sup&gt;, 3&lt;sup&gt;rd&lt;/sup&gt; and 4&lt;sup&gt;th&lt;/sup&gt; terms, 2004, 3&lt;sup&gt;rd&lt;/sup&gt; and 4&lt;sup&gt;th&lt;/sup&gt; terms, 2005</td>
</tr>
<tr>
<td></td>
<td>Year seven</td>
<td></td>
</tr>
<tr>
<td>Parent survey</td>
<td>Year six</td>
<td>2&lt;sup&gt;nd&lt;/sup&gt;, 3&lt;sup&gt;rd&lt;/sup&gt; and 4&lt;sup&gt;th&lt;/sup&gt; terms, 2004</td>
</tr>
<tr>
<td></td>
<td>Year seven</td>
<td>4&lt;sup&gt;th&lt;/sup&gt; term, 2004, 4&lt;sup&gt;th&lt;/sup&gt; term, 2005</td>
</tr>
<tr>
<td>Teacher Interviews</td>
<td>Year six</td>
<td>4&lt;sup&gt;th&lt;/sup&gt; term, 2004</td>
</tr>
<tr>
<td></td>
<td>Year seven</td>
<td>4&lt;sup&gt;th&lt;/sup&gt; term, 2005</td>
</tr>
</tbody>
</table>
for example:

- as students in year seven were keen to discuss the differences between science in primary and science in secondary school, a question was added to the individual interviews allowing students to compare primary and secondary science;
- an additional question which emerged out of focus groups in year six, was added during the interviews in year seven, allowing the students the opportunity to express their ideas of what they would do if they were in charge of planning science for their class (Appendix A);
- it was decided after the attitudinal survey that teachers would be given the opportunity to respond to the results of the study and these would be used in the interpretation of the study and for further recommendations; and
- it was decided that narratives would be used to assist in the interpretation of data when analysis was taking place at the end of 2004 (a discussion regarding narratives is included below).

Patterns were identified in the responses of the participants and the most relevant of these were integrated into the study (Strauss & Corbin, 1997). Literature was referred to in order to support any patterns or new information that emerged from the data. The group and individual responses to the attitudinal survey (Pell & Jarvis, 2001) used to assess the students’ attitudes to science were integrated with other findings to add credibility to the study (Strauss & Corbin, 1997).

The term ‘triangulation’ is commonly used to describe the comparison of information to see if there is confirmation or verification on common concepts or findings (Wiersma, 2000). Wiersma defines triangulation as “qualitative cross-validation” (p. 252). However Bogdan and Biklen (1998) recommend that researchers avoid using the term as it has taken on different meanings in research therefore for the purpose of this study the term ‘cross-validation’ has been used. The ‘cross-validation’ of the multiple data sources in this study increased credibility and trustworthiness, and information in relevant literature was sought to support the interpretation of data (Cresswell, 1998, cited in Glesne, 1999; Glesne & Peshkin, 1992; Anfara et al., 2002). The interpretation of data sources includes students’ views expressed in:

- individual interviews;
focus groups; journal entries; observational reflections; student workbooks; parent surveys; and teacher interviews and anecdotal evidence.

The teacher interviews provided an additional perspective of the students' attitude to, and interest in, science, and the parental surveys provided a picture of how science was perceived in each student's home.

Narratives were developed to establish a picture of each school, class, and student participant as well as to assist in looking for commonalities and differences between students. By compiling narratives using data from all sources, it assisted the researcher in looking at any patterns that emerged and allowed these patterns to be compared within each narrative and with the science education literature (McQueen & Zimmerman, 2006). Samples of these narratives have been included in (Appendices H & I).

Peer audit of data and write up was sought by colleagues as part of this research project and responses were encouraged during discussion sessions after various aspects of the study were presented at conferences3 (Anfara et al., 2002; Cresswell, 1998, cited in Glesne, 1999; Glesne & Peshkin, 1992).

When negative cases emerged from the data these were analysed and the data was revisited to check that other negative cases had not been overlooked (Cresswell, 1998, cited in Glesne, 1999). In order to limit research bias, care was taken to be aware that the researcher may not always interpret the situation as it really is (Glesne, 1999; Glesne & Peshkin, 1992); for example, a student may display interest towards an activity but not

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3 An outline of the research proposal and methodology for this study was presented at the Contemporary Approaches to Research in Mathematics, Science, Health and Environmental Education 2003, Deakin University. Results of the attitudinal survey were presented at the Australasian Science Education Research Association (ASERA) conference (Armidale) in 2004, and results of the case study were presented at ASERA in 2005 (New Zealand) and ASERA in 2006 (Canberra) (for references to conference papers see Preface).
necessarily have a positive attitude towards the subject (Simon, 2000), or a student may utter a positive response towards science when the student does not feel positive towards the subject, in order to please the interviewer. The researcher must also be aware of the fact that these students were chosen to be part of a science study, participated in special activities and were given a voice in science; these factors could result in a ‘Hawthorne Effect’ as the students may see themselves as special (Smith, 2003).

To increase transferability the research methods and interpretation of data are described in fine detail in order to allow someone to repeat the study if desired (Anfara et al., 2002; Taylor & Bogdan, 1998). All transcripts of interviews, and focus groups, field notes of observations, diary reflections and other related documentation of the study have been retained and filed for easy access to enable further checking of the data and interpretation if necessary.

c. Limitations of the Case Study

There are a number of limitations with this case study. These include:

- the small sample size of this study with only four schools where families were generally in the medium to high socio-economic range means the research was quite narrow and it would be unwise to generalise and assume these students’ attitudes to, and interest in, science, represents the attitudes and interest of the majority of Australian students (Osborne et al., 2003). The sample only represents twenty students and eight of these students were selected for an opportunity class as their literacy and numeracy skills were exceptional (see selection procedure 2a(ii) & 3d earlier in the chapter);
- definitions of the constructs ‘attitude’, ‘interest’, ‘motivation’, and ‘engagement’, involve much debate amongst researchers (Simon, 2000) and this could create complications in the interpretation of data because of the abstract nature of the constructs and the many factors or variables involved as discussed in the literature review (Chapter 2);
- the study cannot be completely objective as interpretations vary from one researcher to another (Reiss, 2000). The analysis of responses from questions in interviews and surveys, for example, is open to interpretation: to illustrate this a
student may state that writing is a ‘bad thing about science’ but also respond with
the word ‘writing’ in a response to a different question, such as what is your
favourite subject in school? The student may be referring to copying of notes as a
‘bad thing about science’ and creative writing as a response to ‘what is your
favourite subject at school?’ or words such as ‘boring’, as a response, may have
different meanings for different students, for example, ‘boring’ may mean that an
activity is too difficult with one student or unchallenging with another (Baird et aI.,
1990);

- the use of transcripts creates problems in interpretation of data, for example, a
conversation which appears coherent at the time could appear “confused and
disorganised” when transcribed (Lemke, 1998);
- as interviews were semi-structured, although care was taken to repeat the same
wording of the question to each student participant, flexibility in the wording to
assist the student in the interpretation of the questions may have resulted in
different responses from different students, therefore reducing comparability of
responses (Patton, 1990);
- it would have been preferable to have collected all data within the same term each
year for consistency, but time restrictions due to the large amount of data and
factors such as a number of additional students coming into the study late in the
year in 2004, meant this was not possible (Table 3.4); and
- as some students may wish to be seen to be doing “the done thing” by their peers
during focus groups and classroom observations, students may not be completely
honest about their feelings towards activities or towards science in general (Simon,
2000, p. 106).

**d. Strengths of the Research**

Even though the case study and attitudinal survey are relatively small studies, looking at
the ideas that emerge in the data and linking this information to material in relevant
literature has provided rich insight into factors that influence students’ attitudes to, and
interest in, science and what leads to motivation and engagement in the classroom. The
urgency to address the problem of negative attitudes to science is apparent from the
research literature and the call to re-imagine science to make the subject more relevant for
today’s world is coming across loud and clear (Tytler, 2007a); therefore research in this area is vital.

“This project was a longitudinal, essentially qualitative, study and there are relatively few longitudinal, or qualitative studies, that have looked at the attitudes of students towards science, particularly those involving individual or group interviews (Osborne et al., 2003; Reiss, 2000). An ‘in depth’ study such as this looking at the changes in attitude to, and interest in, science, over the primary/secondary interface (in year six and again in year seven), allows the researcher a glimpse from the students’ perspective to determine what it is that ‘switches them on to’ science. This study gave the students a voice and the researcher endeavoured to see the world from each student’s perspective by the use of multiple methods of data collection to gain knowledge of how and why these attitudes have changed as the students entered secondary school, what has lead to motivation towards science, engagement with science activities or what interests them in the subject (Ferguson & Fraser, 1998; Pell & Jarvis, 2001; Jenkins & Pell, 2006). Taking these factors into consideration and the urgency to address this issue it would seem that this study is very significant”.

The aim of science education generally is for students to achieve ‘scientific literacy’ (Goodrum et al., 2001) and, as stated, research has shown that students’ attitudes towards science tend to become less positive as they progress through school (Baird et al., 1990; James & Smith, 1985; Jarvis & Pell, 2001; Murphy & Beggs, 2003; Simpson & Oliver, 1990). Therefore identifying some of the factors that influence the students’ attitudes to, and interest in, science even with a small group of students may allow teachers and curriculum developers both at primary and secondary levels to address these areas for the future presentation of science, hopefully making science more relevant to the students’ lives and maybe increasing the chances of students maintaining their interest and eventually becoming scientifically literate, or developing a ‘personal interest’ in the subject and/or pursuing a career in science.

**Summary**

This chapter describes the research design of the study. The study includes a quantitative component, an attitudinal survey, but it essentially is a qualitative case study
and with these mixed methods it could be considered to be consistent with a pragmatist paradigm. The theoretical stance that underpins the methodology of this case study is symbolic interactionism and the methodology is essentially phenomenology. The attitudinal survey involved the use of a validated attitudinal questionnaire (Pell & Jarvis, 2001) that was administered to a wider cross section of students to obtain a more encompassing ‘picture’ of student attitudes towards science across the interface and into the secondary years. The case study involved a longitudinal study following a group of 21 students as they moved from primary into secondary school to look at how their attitude to, and interest in, science, changed. It also examined the factors that caused a change in attitude to, and interest in, science. The case study sought to listen to the voice of the students and discover what led to motivation and engagement in the subject. Although the case study was a relatively small sample, the multiple data sources used and the narratives that were developed from all data sources provided rich insight into the attitudes to, and interest in, science of the 20 remaining students and allowed the researcher to gain a glimpse of science from the eyes of these students.

Outline of the Following Two Chapters

Chapter 4 outlines the findings of the cross-sectional attitudinal study which is the quantitative component of this research project and Chapter 5 outlines the findings of the case study which is the main focus of this doctoral thesis.
RESULTS

Introduction

The following two chapters outline the results of this study looking at the changes in students’ attitudes to, and interest in, science as the students move from year six primary school into year seven secondary school. The study involved two components:

1. a qualitative longitudinal ‘case study’ involving 21 students who were in year six in 2004 and in year seven in 2005; and
2. a quantitative ‘attitudinal survey’ administered to 264 students in the classes from which the sample students in the case study were selected. It was also applied to a wider cross section of students from years 5 to 10 to obtain a more encompassing ‘picture’ of students’ attitudes towards science across the interface and into the secondary years (for more information refer to Chapter 3).

This Chapter outlines the results of the attitudinal survey and Chapter 5 outlines the results of the case study.

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1 The data and analysis in this chapter did not include the data of six participant students in the case study because their data was collected at a later stage. However, their data does not influence the overall findings of the results.
RESULTS 1: THE ATTITUDINAL SURVEY

This chapter is divided into the following sections:
1. the attitudinal survey: structure, reliability and methods of analysis;
2. results for the various attitudinal study components, derived sub-scales and the composite ‘Science interest’ sub-scale;
3. overall summary of results;
4. an overview of responses of primary and secondary teachers to the results of the attitudinal survey; and
5. how the attitudinal survey relates to the case study.

1. The Attitudinal Survey: Structure, Reliability and Methods of Analysis

Structure

The instrument used in this attitudinal survey was a validated attitudinal questionnaire developed by Pell and Jarvis (2001). The instrument consists of a ‘smiley face’ Likert scale containing 43 items, divided into three categories and an open-ended question, which allowed students to give a written response to a ‘good’ and ‘bad’ thing about science. The three categories, their derived sub-scales and a composite scale are as follows:

- ‘Being in school’; (derived sub-scale; ‘Liking school’)
- ‘Science experiments’; (derived subscale; ‘Individual investigator’); and
- ‘What I really think of science’ (derived subscales; ‘Science enthusiasm’, ‘Social context’, and ‘Difficult science’); and

An explanation of the analysis of the results is included below with a description of the sub-scales and composite scale. Following on from this are the results for each of the three scales, their derived sub-scales, and the composite scale ‘Science interest’ (Pell & Jarvis) listed above. Gender and ability differences are presented for the various sub-scales and ‘Science interest’, and the trends overall are summarised. Finally, the responses of primary and secondary teachers to the results of the attitudinal study are overviewed.
Chapter Four

Instrument reliability and Method of Analysis is outlined in the research design and method (Chapter 3, Section 2a) and an abbreviated version has been included in this chapter to remind the reader before reading the results, how the analysis was undertaken.

**Instrument Reliability**

This instrument had suitable reliability statistics for its various subscales (Pell & Jarvis, 2001) and similar or better scale reliabilities were found when the questionnaire was used in the present study (Chapter 3, Table 3.1).

**Methods of Analysis**

Analysis of the quantitative responses to the survey was completed using the Statistical Package for the Social Sciences (SPSS). As all items were worded to avoid negative phraseology, which Pell and Jarvis (2001) argued would make these items more accessible to young children, all items were recoded (5=1, 4=2 etc.) in order that high interest could be aligned with high scores and the low interest aligned with low scores. The means for the individual items in the three categories (outlined above under 'structure') across the primary and secondary divisions, were compared by determining the distribution of responses using chi-square (Table 4.1), and independent t-tests (Tables 4.2 & 4.3). Scores for the derived sub-scales of ‘Liking school’ (10 items using a five point scale; maximum score 50, ‘Being in School’ items 4 and 11 from Table 4.1 deleted), ‘Independent investigator’ (9 items using a 5 point scale; max 45, ‘Science experiments’ item 7 deleted, Table 4.2), ‘Science enthusiast’ (8 items using a 3 point scale; max 24, Table 4.3), ‘Social context’ (8 items using a 3 point scale; max 24, Table 4.3) and ‘Difficult science’ (5 items using a 3 point scale; max 15, Table 4.3), and the composite scale of ‘Science interest’ (25 items; maximum 75, comprising the sub-scales of ‘Independent investigator’, ‘Science enthusiast’ and ‘Social context’ [in which the ‘Individual investigator’ sub-scale item responses were collapsed from a five point scale to a three point scale so that the three point sub-scales could be added together]) were calculated. Means for these derived and composite scales were compared across primary and secondary cohorts (independent t-tests) (Tables 4.4 & 4.5). These two tables also compare mean scores for boys and girls separately across the primary and secondary cohorts as well as students of higher and
lesser ability across the primary secondary cohorts. The tables also show scores across individual School Years (ANOVA) (Tables 4.8 & 4.9). Differences between males and females within primary and secondary school and years (Table 4.6 & 4.10) and students of different ability within primary and secondary school and years (Tables 4.7 & 4.11) were also determined. These tables are shown on the following page. A discussion of these tables and apparent patterns then follows.

2. Results of the various Attitudinal Survey Components, Derived Sub-scales and the Composite ‘Science Interest’ Scale

a. Results for ‘Being in School’ Scale

There were 12, five-point Likert items related to the ‘Being in school’ main scale, of which ten were retained by Pell and Jarvis (2001) for the derived ‘Liking school’ sub-scale (items 4 and 11 in Table 4.1 were deleted). Responses across the primary-secondary interface for all twelve items are shown in Table 4.1, with comparisons for the Pell and Jarvis primary (years one to six) data. These data indicate that significantly less secondary students liked coming to school, reading, using the computer and writing in their science books than primary students. It was noted that ‘writing in your science book’ was the lowest item mean score (2.72) for secondary students (cf. primary 3.42) whereas ‘using the computer’/‘working with friends’ (both 4.63) and ‘doing science experiments’ (4.49) were the highest item mean scores for primary; the last mentioned, ‘doing science experiments’ still remained popular in secondary school (4.16). This trend appeared consistent with the short response questions (Tables 4.13 & 4.14) where 44.7% of primary and 64.8% of secondary students wrote ‘practical work or experiments’ in the category ‘a good thing about science’ and 33.3% of primary students and 47% of secondary students stated that ‘theory/writing’ were ‘bad things about science’.

1 It should be noted that these tables (Tables 4.8 & 4.9) are not comparing boys with girls and students of higher ability and lesser ability; they are comparing differences across the primary/secondary interface.
Table 4.1

*Item Responses for Primary and Secondary ‘Being in school’*

<table>
<thead>
<tr>
<th>Item Description</th>
<th>Primary</th>
<th>Secondary</th>
</tr>
</thead>
<tbody>
<tr>
<td>How do you feel about</td>
<td>Mean (cf. Pell &amp; Jarvis, 2001)</td>
<td></td>
</tr>
<tr>
<td>1. Writing</td>
<td>3.71 (4.03)</td>
<td>3.41</td>
</tr>
<tr>
<td>2. Reading</td>
<td>4.07 (4.18)</td>
<td>3.83**</td>
</tr>
<tr>
<td>3. Spelling</td>
<td>3.29 (3.74)</td>
<td>3.02</td>
</tr>
<tr>
<td>4. Drawing</td>
<td>4.39 (4.32)</td>
<td>4.16</td>
</tr>
<tr>
<td>5. Doing sums</td>
<td>3.18 (3.71)</td>
<td>2.97</td>
</tr>
<tr>
<td>6. Working with shapes</td>
<td>3.33 (3.41)</td>
<td>3.03</td>
</tr>
<tr>
<td>7. Using the computer</td>
<td>4.63 (4.79)</td>
<td>4.31**</td>
</tr>
<tr>
<td>8. Doing science experiments</td>
<td>4.49 (4.05)</td>
<td>4.16</td>
</tr>
<tr>
<td>9. Writing in your science book</td>
<td>3.42 (3.54)</td>
<td>2.72**</td>
</tr>
<tr>
<td>10. Working by yourself</td>
<td>3.42 (3.54)</td>
<td>3.26</td>
</tr>
<tr>
<td>11. Working with your friends</td>
<td>4.63 (4.56)</td>
<td>4.58</td>
</tr>
<tr>
<td>12. Coming to school</td>
<td>3.68 (3.91)</td>
<td>3.47*</td>
</tr>
</tbody>
</table>

*Note.* For each item the five point score distributions were tested by Chi-square *p<.05,**p<0.01 (Pell & Jarvis, 2001). For the sub-scale ‘liking school’ items 4 and 11 were deleted.
Table 4.2

*Item Responses for ‘Science Experiments’*

<table>
<thead>
<tr>
<th>How do you feel about</th>
<th>Primary (Years 5 and 6)</th>
<th>Secondary (Years 7-10)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean (cf. Pell &amp; Jarvis, 2001)</td>
<td>N</td>
<td>SD</td>
</tr>
<tr>
<td>1. Watching the teacher do an experiment</td>
<td>3.80 (3.98)</td>
<td>95</td>
</tr>
<tr>
<td>2. Working out what to do yourself</td>
<td>3.69 (3.47)</td>
<td>95</td>
</tr>
<tr>
<td>3. Teacher telling you what to do</td>
<td>3.29 (3.91)</td>
<td>95</td>
</tr>
<tr>
<td>4. Choosing your own equipment</td>
<td>4.62 (4.49)</td>
<td>95</td>
</tr>
<tr>
<td>5. Finding out what happens yourself</td>
<td>4.35 (3.99)</td>
<td>95</td>
</tr>
<tr>
<td>7. Working with friends</td>
<td>4.76 (4.46)</td>
<td>94</td>
</tr>
<tr>
<td>8. Finding out why the experiment works</td>
<td>4.12 (3.88)</td>
<td>95</td>
</tr>
<tr>
<td>9. Telling teacher what you have done</td>
<td>3.64 (4.03)</td>
<td>95</td>
</tr>
<tr>
<td>10. Telling friends what you have done</td>
<td>3.98 (3.54)</td>
<td>95</td>
</tr>
</tbody>
</table>

*Note.* For each item differences were tested using independent t-tests *p<.05, **p<0.01. For the sub-scale ‘independent investigator’ item 7 was deleted.
### Item Responses for 'What I Really Think of Science' Sub-scales

<table>
<thead>
<tr>
<th>Item (ordered by sub-scale)</th>
<th>Primary</th>
<th>Secondary</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Science Enthusiast</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. I should like to be a scientist</td>
<td>1.71 (1.98)</td>
<td>94</td>
</tr>
<tr>
<td>5. I like science more than any other school work</td>
<td>1.56 (1.81)</td>
<td>94</td>
</tr>
<tr>
<td>6. I often do science experiments at home</td>
<td>1.75 (1.77)</td>
<td>93</td>
</tr>
<tr>
<td>13. I like to watch science programs on TV</td>
<td>2.11 (2.32)</td>
<td>95</td>
</tr>
<tr>
<td>14. School science clubs are a good idea</td>
<td>2.23 (2.48)</td>
<td>95</td>
</tr>
<tr>
<td>16. I am always reading science stories</td>
<td>1.47 (1.74)</td>
<td>95</td>
</tr>
<tr>
<td>17. I should like to be given a science kit as a present</td>
<td>2.21 (2.52)</td>
<td>95</td>
</tr>
<tr>
<td>20. One day, I should like to go to the moon</td>
<td>2.21 (2.45)</td>
<td>95</td>
</tr>
<tr>
<td><strong>Social Context</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Science is good for everybody</td>
<td>2.32 (2.48)</td>
<td>94</td>
</tr>
<tr>
<td>3. Lots more money should be spent on science</td>
<td>2.18 (2.15)</td>
<td>94</td>
</tr>
<tr>
<td>8. It is easy to find out new things in science lessons</td>
<td>2.66 (2.37)</td>
<td>94</td>
</tr>
<tr>
<td>9. Science has made us better and safer medicines</td>
<td>2.79 (2.59)</td>
<td>94</td>
</tr>
<tr>
<td>10. TV, telephones and radio have all required science</td>
<td>2.64 (2.46)</td>
<td>94</td>
</tr>
<tr>
<td>11. Our food is safer thanks to science</td>
<td>2.38 (2.37)</td>
<td>94</td>
</tr>
<tr>
<td>15. Science makes me think</td>
<td>2.69 (2.56)</td>
<td>95</td>
</tr>
<tr>
<td>19. Science can make chemicals we need from rocks <em>(Table 4.3 continued next page)</em></td>
<td>2.41 (2.33)</td>
<td>95</td>
</tr>
</tbody>
</table>
(Table 4.3 continued)

*Item responses for 'what I really think of science' subscales (continued)*

<table>
<thead>
<tr>
<th>Item (ordered by sub-scale)</th>
<th>Primary</th>
<th>Secondary</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>N</td>
</tr>
<tr>
<td></td>
<td>(cf. Pell &amp; Jarvis, 2001)</td>
<td></td>
</tr>
<tr>
<td><strong>Difficult science</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. You have to be clever to do science</td>
<td>1.87 (2.27)</td>
<td>94</td>
</tr>
<tr>
<td>7. Science is just too difficult</td>
<td>1.53 (1.85)</td>
<td>94</td>
</tr>
<tr>
<td>12. We have to do too much work in science</td>
<td>1.61 (2.08)</td>
<td>95</td>
</tr>
<tr>
<td>18. We do too much science at school</td>
<td>1.88 (1.88)</td>
<td>95</td>
</tr>
<tr>
<td>20. We have to do too much writing in science</td>
<td>2.00 (2.10)</td>
<td>95</td>
</tr>
</tbody>
</table>

*Note.* For each item differences were tested using independent t-tests *p*<.05, **p*<0.01. The mean scores for 'Science enthusiasm' are markedly lower than 'Social context', and the item means for 'difficult science' increase in secondary.
Table 4.4

Sub-scale Scores for Primary and Secondary Cohorts and Differences between Primary and Secondary Boys and Primary and Secondary Girls (i.e., Across the Primary/Secondary Interface)

<table>
<thead>
<tr>
<th>Derived sub-scale</th>
<th>Max Score</th>
<th>Primary Mean (cf. Pell &amp; Jarvis, 2001)</th>
<th>Secondary Mean</th>
<th>Primary SD</th>
<th>N</th>
<th>Secondary SD</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Liking school (10 items)</td>
<td>50</td>
<td>M37.07 37.45 5.82 92</td>
<td>F33.79 34.14** 6.16 166</td>
<td>44</td>
<td>66</td>
<td>48</td>
<td>100</td>
</tr>
<tr>
<td>2. Independent investigator (9 items)</td>
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Note. Significant difference between primary and secondary means two tailed t-test *p<.05, **p<.01. M=male and F=female. Underlined figures are the total primary or total secondary means (male and female means combined) for each sub-scale.
Table 4.5

Sub-scale Scores for Primary and Secondary Cohorts and Differences Across the Primary/Secondary Interface for Higher Ability Primary and Secondary Students and Primary and Secondary Students of Lesser Ability

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*Note.* Significant difference between primary and secondary means two tailed t-test *p*<.05, **p*<.01; H = High Ability, O = Other. See table 4.4 for maximum score and item no of each sub-scale. Underlined figures are the total primary or total secondary means (high ability and other ability means combined) for each sub-scale.
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Note. Significant difference between primary and secondary means two tailed t-test
*p<.05, **p<.01. See table 4.4 for maximum score and item no of each sub-scale.
M=male and F=female. Underlined figures are the total primary or total secondary
means (male and female means combined) for each sub-scale.
Table 4.7

Sub-scale Scores for Primary and Secondary Cohorts and Differences Between Primary Students of Different Ability and Secondary Students of Different Ability

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Note. Significant difference between primary and secondary means two-tailed t-test *p<.05, **p<.01, H = High Ability, O = Other. See table 4.4 for maximum score and item no of each sub-scale. Underlined figures are the total primary or total secondary means (high ability and other means combined) for each sub-scale.
### Chapter Four

#### Table 4.8

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<td></td>
</tr>
<tr>
<td></td>
<td>M38.14</td>
<td>36.57</td>
<td>35.31</td>
<td>34.6</td>
<td>33.92</td>
<td>35.12</td>
<td>33.55</td>
</tr>
<tr>
<td>Independent investigator</td>
<td>34.34[*9,10]</td>
<td>35.41[*7,9,10]</td>
<td>31.23[*6]</td>
<td>32.17</td>
<td>30.29</td>
<td>29.60[*5,6]</td>
<td></td>
</tr>
<tr>
<td></td>
<td>M36.44</td>
<td>34.73</td>
<td>31.69</td>
<td>33.08</td>
<td>31.55</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Science enthusiast</td>
<td>15.31[*7,9,10]</td>
<td>15.16[*7,9,10]</td>
<td>12.51[*5,6]</td>
<td>14.13</td>
<td>12.00[*5,6]</td>
<td>12.59[*5,6]</td>
<td></td>
</tr>
<tr>
<td></td>
<td>M16.47</td>
<td>15.17</td>
<td>13.16</td>
<td>14.57</td>
<td>13.31</td>
<td>13.60</td>
<td></td>
</tr>
<tr>
<td></td>
<td>M20.81</td>
<td>20.60</td>
<td>18.80</td>
<td>20.14</td>
<td>21.23</td>
<td>21.00</td>
<td></td>
</tr>
<tr>
<td></td>
<td>F9.96</td>
<td>8.40</td>
<td>10.11</td>
<td>9.52</td>
<td>8.94</td>
<td>10.26</td>
<td></td>
</tr>
<tr>
<td>Science interest</td>
<td>58.08[*7,10]</td>
<td>59.11[*7,10]</td>
<td>52.01[*5,5]</td>
<td>55.53</td>
<td>52.88[*6]</td>
<td>52.21[*5,6]</td>
<td></td>
</tr>
<tr>
<td></td>
<td>M61.53[*7]</td>
<td>58.80</td>
<td>53.28[*5]</td>
<td>56.08</td>
<td>56.69</td>
<td>56.44</td>
<td></td>
</tr>
</tbody>
</table>

**Note.** Significant difference between means ANOVA; Tukey test *p<.05 or p<.01, M = Male, F= Female, [*N] = significant difference between years. See table 4.4 for maximum score and item no of each sub-scale. Underlined figures are the total means of each year level (male and female means combined) for each sub-scale.
### Table 4.9

**Sub-scale Scores for Primary and Secondary Year Levels and Differences Across the Year Levels for Students of High Ability and Students of Lesser Ability.**

<table>
<thead>
<tr>
<th>Year Level</th>
<th>Primary</th>
<th>Secondary</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Derived</td>
<td>Derived</td>
</tr>
<tr>
<td></td>
<td>sub-scale</td>
<td>sub-scale</td>
</tr>
<tr>
<td>Primary</td>
<td>(n=37)</td>
<td>(n=55)</td>
</tr>
<tr>
<td></td>
<td>(H n=7)</td>
<td>(H n=12)</td>
</tr>
<tr>
<td></td>
<td>O n=30</td>
<td>O n=43</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>n=72</td>
<td>n=20-22</td>
</tr>
<tr>
<td>Derived</td>
<td>O n=72</td>
<td>O n=20-22</td>
</tr>
<tr>
<td>sub-scale</td>
<td>O n=72</td>
<td>O n=20-22</td>
</tr>
<tr>
<td>Liking</td>
<td>36.86[*10]</td>
<td>37.83[*10]</td>
</tr>
<tr>
<td>school</td>
<td>38.00</td>
<td>40.00</td>
</tr>
<tr>
<td>Derived</td>
<td>O 36.69[*10]</td>
<td>O 37.17[*10]</td>
</tr>
<tr>
<td>Liking</td>
<td>34.34[*9,10]</td>
<td>35.41[*7,9,10]</td>
</tr>
<tr>
<td>school</td>
<td>36.71</td>
<td>37.38</td>
</tr>
<tr>
<td>Science</td>
<td>15.31[*7,9,10]</td>
<td>15.16[*7,9,10]</td>
</tr>
<tr>
<td>context</td>
<td>H 20.00</td>
<td>21.41</td>
</tr>
<tr>
<td>science</td>
<td>H 8.29</td>
<td>8.08</td>
</tr>
<tr>
<td>Science</td>
<td>58.08</td>
<td>59.11[*8]</td>
</tr>
<tr>
<td>interest</td>
<td>H 62.3</td>
<td>62.4[*8]</td>
</tr>
<tr>
<td>Derived</td>
<td>O 57.5[*7,9,**10]</td>
<td>O 58[*7,9,10]</td>
</tr>
</tbody>
</table>

**Note.** Significant difference between means ANOVA; Tukey test *p<.05, **p<.01, H = High, O = Other, [*N] = significant difference between years. See table 4.4 for maximum score and item no of each sub-scale. Underlined figures are the total year level mean (high and other means combined) for each sub-scale.
Table 4.10

Sub-scale Scores for Primary and Secondary Year Levels and Differences Between Males and Females at Each Year Level

<table>
<thead>
<tr>
<th>Year Level</th>
<th>Primary</th>
<th>Secondary</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Male (n=37-39)</td>
<td>Male (n=55)</td>
</tr>
<tr>
<td></td>
<td>Female (n=14-16)</td>
<td>Male (n=30)</td>
</tr>
<tr>
<td>Derived sub-scale</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Liking school</td>
<td>36.86</td>
<td>37.83</td>
</tr>
<tr>
<td></td>
<td>M38.14</td>
<td>36.57*</td>
</tr>
<tr>
<td></td>
<td>F36.09</td>
<td>39.36</td>
</tr>
<tr>
<td>Independent investigator</td>
<td>34.34</td>
<td>35.41</td>
</tr>
<tr>
<td></td>
<td>M36.44*</td>
<td>34.73</td>
</tr>
<tr>
<td></td>
<td>F32.82</td>
<td>36.19</td>
</tr>
<tr>
<td>Science enthusiast</td>
<td>15.31</td>
<td>15.16</td>
</tr>
<tr>
<td></td>
<td>M16.47</td>
<td>15.17</td>
</tr>
<tr>
<td></td>
<td>F14.56</td>
<td>15.16</td>
</tr>
<tr>
<td></td>
<td>M20.81*</td>
<td>20.60</td>
</tr>
<tr>
<td></td>
<td>F18.52</td>
<td>20.40</td>
</tr>
<tr>
<td>Difficult science</td>
<td>9.48</td>
<td>8.51</td>
</tr>
<tr>
<td></td>
<td>M8.81</td>
<td>8.60</td>
</tr>
<tr>
<td></td>
<td>F9.96</td>
<td>8.40</td>
</tr>
<tr>
<td>Science interest</td>
<td>58.08</td>
<td>59.11</td>
</tr>
<tr>
<td></td>
<td>M61.53**</td>
<td>58.80</td>
</tr>
<tr>
<td></td>
<td>F55.72</td>
<td>59.48</td>
</tr>
</tbody>
</table>

Note. Significant difference between means t-test *p<.05, **p<.01, M= Male, F = Female. See table 4.4 for maximum score and item no of each sub-scale. Underlined figures are the total year level mean (male and female means combined) for each sub-scale.
### Table 4.11

**Sub-scale Scores for Primary and Secondary Year Levels and Differences Between Students of High Ability and Students of Lesser Ability at Each Year Level**

<table>
<thead>
<tr>
<th>Year Level</th>
<th>Primary</th>
<th>Secondary</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Derived sub-scale</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(High n=7</td>
<td>Other n=30)</td>
</tr>
<tr>
<td>5 (n=37)</td>
<td>36.86</td>
<td>34.87</td>
</tr>
<tr>
<td>6 (n=55)</td>
<td>37.83</td>
<td>34.83</td>
</tr>
<tr>
<td>7 (n=70)</td>
<td>36.36*</td>
<td>35.00</td>
</tr>
<tr>
<td>8 (n=30)</td>
<td>34.22</td>
<td>34.62</td>
</tr>
<tr>
<td>9</td>
<td>33.17</td>
<td>34.22</td>
</tr>
<tr>
<td>10 (n=28)</td>
<td>37.17</td>
<td>34.22</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Liking school</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(High n=12</td>
<td>Other n=43)</td>
</tr>
<tr>
<td>H 38.00</td>
<td>36.36*</td>
<td>35.00</td>
</tr>
<tr>
<td>O 36.60</td>
<td>34.22</td>
<td>34.62</td>
</tr>
<tr>
<td>H 36.71</td>
<td>37.17</td>
<td>34.22</td>
</tr>
<tr>
<td>O 33.81</td>
<td>34.22</td>
<td>34.62</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Independent investigator</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(High n=13</td>
<td>Other n=22)</td>
</tr>
<tr>
<td>H 36.71</td>
<td>37.17</td>
<td>34.22</td>
</tr>
<tr>
<td>O 33.81</td>
<td>34.22</td>
<td>34.62</td>
</tr>
<tr>
<td>H 36.71</td>
<td>37.17</td>
<td>34.22</td>
</tr>
<tr>
<td>O 33.81</td>
<td>34.22</td>
<td>34.62</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Science enthusiast</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(High n=21</td>
<td>Other n=13)</td>
</tr>
<tr>
<td>H 17.43</td>
<td>36.36*</td>
<td>35.00</td>
</tr>
<tr>
<td>O 14.84</td>
<td>34.22</td>
<td>34.62</td>
</tr>
<tr>
<td>H 17.43</td>
<td>37.17</td>
<td>34.22</td>
</tr>
<tr>
<td>O 33.81</td>
<td>34.22</td>
<td>34.62</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Social context</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(High n=21</td>
<td>Other n=13)</td>
</tr>
<tr>
<td>H 20.00</td>
<td>36.36*</td>
<td>35.00</td>
</tr>
<tr>
<td>O 19.34</td>
<td>34.22</td>
<td>34.62</td>
</tr>
<tr>
<td>H 20.00</td>
<td>37.17</td>
<td>34.22</td>
</tr>
<tr>
<td>O 33.81</td>
<td>34.22</td>
<td>34.62</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Difficult science</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(High n=21</td>
<td>Other n=13)</td>
</tr>
<tr>
<td>H 8.29</td>
<td>36.36*</td>
<td>35.00</td>
</tr>
<tr>
<td>O 9.75</td>
<td>34.22</td>
<td>34.62</td>
</tr>
<tr>
<td>H 8.29</td>
<td>37.17</td>
<td>34.22</td>
</tr>
<tr>
<td>O 33.81</td>
<td>34.22</td>
<td>34.62</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Science interest</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(High n=21</td>
<td>Other n=13)</td>
</tr>
<tr>
<td>H 62.3</td>
<td>56.2*</td>
<td>55.3</td>
</tr>
<tr>
<td>O 57.5</td>
<td>50.6</td>
<td>55.9</td>
</tr>
<tr>
<td>H 62.3</td>
<td>56.2*</td>
<td>55.3</td>
</tr>
<tr>
<td>O 57.5</td>
<td>50.6</td>
<td>55.9</td>
</tr>
</tbody>
</table>

**Note.** Significant difference between means t-test *p<.05, **p<.01, H = High Ability, O = Other. See table 4.4 for maximum score and item no of each sub-scale. Underlined figures are the total year level means (male and female means combined) for each sub-scale.
Table 4.12

**Correlations Between Sub-scale Scores for Boys and Girls**

<table>
<thead>
<tr>
<th>Derived sub-scale</th>
<th>Liking school</th>
<th>Independent investigator</th>
<th>Science enthusiast</th>
<th>Social context</th>
<th>Difficult science</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>r</td>
<td>N</td>
<td>r</td>
<td>N</td>
<td>r</td>
</tr>
<tr>
<td>Liking school</td>
<td>0.66</td>
<td>147</td>
<td>0.46</td>
<td>146</td>
<td>0.43</td>
</tr>
<tr>
<td>(0.69)</td>
<td>(0.36)</td>
<td>(0.39)</td>
<td>(0.13)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Independent investigator</td>
<td>0.69</td>
<td>109</td>
<td>-</td>
<td>-</td>
<td>0.49</td>
</tr>
<tr>
<td>(0.66)</td>
<td>(0.33)</td>
<td>(0.48)</td>
<td>(0.04)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Science enthusiast</td>
<td>0.34</td>
<td>107</td>
<td>0.47</td>
<td>109</td>
<td>-</td>
</tr>
<tr>
<td>(0.33)</td>
<td>(0.38)</td>
<td>(0.47)</td>
<td>(0.12)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Social context</td>
<td>0.34</td>
<td>107</td>
<td>0.32</td>
<td>110</td>
<td>0.49</td>
</tr>
<tr>
<td>(0.43)</td>
<td>(0.48)</td>
<td>(0.44)</td>
<td>(0.06)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Difficult science</td>
<td>-0.53</td>
<td>107</td>
<td>-0.33</td>
<td>110</td>
<td>-0.28</td>
</tr>
<tr>
<td>(0.00)</td>
<td>(0.01)</td>
<td>(0.10)</td>
<td>(0.09)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Note.** Correlation coefficient significant p<0.05; Compare Jarvis & Pell (2001), (in parentheses)
Table 4.13

*Frequency of Student Responses to the Open-Ended Item: ‘A Good Thing About Science’*

<table>
<thead>
<tr>
<th>Category</th>
<th>Primary</th>
<th>N</th>
<th>Secondary</th>
<th>N</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Practical Work or experiments</td>
<td>43 (44.7%)</td>
<td>96</td>
<td>109 (64.8%)</td>
<td>168</td>
<td>152 (57.5%)</td>
</tr>
<tr>
<td>Learning new Things</td>
<td>29 (30%)</td>
<td>96</td>
<td>49 (29%)</td>
<td>168</td>
<td>78 (29.5%)</td>
</tr>
<tr>
<td>Interesting/fun</td>
<td>16 (16.6%)</td>
<td>96</td>
<td>8 (4.7%)</td>
<td>168</td>
<td>24 (9%)</td>
</tr>
<tr>
<td>Science relates to life/useful</td>
<td>1 (1%)</td>
<td>96</td>
<td>7 (4.1%)</td>
<td>168</td>
<td>8 (3%)</td>
</tr>
<tr>
<td>World Science Issues (medical, technology etc.)</td>
<td>6 (6.2%)</td>
<td>96</td>
<td>2 (1%)</td>
<td>168</td>
<td>8 (3%)</td>
</tr>
<tr>
<td>Other</td>
<td>8 (8.8%)</td>
<td>96</td>
<td>9 (5%)</td>
<td>168</td>
<td>17 (6.4%)</td>
</tr>
<tr>
<td>Nothing good</td>
<td>1 (1%)</td>
<td>96</td>
<td>4 (2.3%)</td>
<td>168</td>
<td>5 (1.5%)</td>
</tr>
<tr>
<td>No Response</td>
<td>3 (3%)</td>
<td>96</td>
<td>1 (1.7%)</td>
<td>168</td>
<td>4 (1.5%)</td>
</tr>
</tbody>
</table>

*Note:* Some students’ responses fell into more than one category.
### Table 4.14

**Frequency of Student Responses to the Open-Ended Item: ‘A Bad Thing About Science’**

<table>
<thead>
<tr>
<th>Category</th>
<th>Primary</th>
<th>N</th>
<th>Secondary</th>
<th>N</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Theory/writing</td>
<td>32 (33.3%)</td>
<td>96</td>
<td>79 (47%)</td>
<td>168</td>
<td>111 (42%)</td>
</tr>
<tr>
<td>Teacher related Comments</td>
<td>4 (4%)</td>
<td>96</td>
<td>44 (26%)</td>
<td>168</td>
<td>48 (18%)</td>
</tr>
<tr>
<td>Too difficult</td>
<td>13 (13.5%)</td>
<td>96</td>
<td>23 (13.7%)</td>
<td>168</td>
<td>36 (13.6%)</td>
</tr>
<tr>
<td>Science is (or Sometimes is) boring</td>
<td>9 (9.3%)</td>
<td>96</td>
<td>16 (9.5%)</td>
<td>168</td>
<td>25 (9.5%)</td>
</tr>
<tr>
<td>World science (reputation, genetics, war, depressing science, pollution etc)</td>
<td>4 (4.2%)</td>
<td>96</td>
<td>5 (3%)</td>
<td>168</td>
<td>9 (3.4%)</td>
</tr>
<tr>
<td>Nothing bad</td>
<td>12 (12.5%)</td>
<td>96</td>
<td>2 (1%)</td>
<td>168</td>
<td>14 (5.3%)</td>
</tr>
<tr>
<td>Other</td>
<td>20 (20.8%)</td>
<td>96</td>
<td>20 (11.9%)</td>
<td>168</td>
<td>40 (15.2%)</td>
</tr>
<tr>
<td>No response</td>
<td>5 (5.2%)</td>
<td>96</td>
<td>1 (0.6%)</td>
<td>168</td>
<td>6 (2.3%)</td>
</tr>
</tbody>
</table>

*Note.* Some students’ responses fell into more than one category.
Chapter Four

Results for the ‘Being in school’ Sub-Scale ‘Liking school’

The derived ‘Liking school’ sub-scale (ten items, five-point likert scale) mean declined significantly from primary (37.45) to secondary (34.14), and these declines were present for males and females (see Table 4.4) as well as for students of higher and lower ability (Table 4.5). However there were no differences between males and females at the primary and secondary levels respectively but students of higher ability scored significantly higher than those of lower ability at both primary and secondary levels (Tables 4.6 & 4.7). When the differences across years six and seven are considered separately (Tables 4.8 & 4.9) no overall significant differences were observed, although there was a significant decline in ‘Liking school’ scores for year seven females (Table 4.8). Further, at year six, females liked school more than males, although this difference was not present at any later year levels, while higher ability students liked school more at year seven (and also in years nine and ten) (Tables 4.10 & 4.11).

b. Results for ‘Science Experiments’ Scale

Of the ten items for this main scale (Table 4.2) seven items showed a significant decline in distributions of the responses for secondary students. In declining order secondary students liked less to ‘work with friends’ (4.53), ‘choose their own equipment’ (3.78), ‘find out why the experiment works’ (3.71), ‘tell friends what you have done’ (3.51), ‘work out what to do yourself’ (3.27), ‘tell teacher what you have done’ (3.15) and ‘watching the teacher do an experiment’ (3.08). Three of these items imply that the student is making ‘investigation’ decisions. The highest item mean scores for primary students were ‘choosing your own equipment’ (4.62) and ‘working with friends’ (4.76); in secondary it was still ‘working with friends’ (4.53), while the two lowest scores were ‘watching the teacher do an experiment’ (3.08) and ‘teacher telling you what to do’ (3.16) which suggest that the student is in a passive role. These students would prefer to be taking part in more student-centred learning where they choose their own equipment, work collaboratively with friends and design their own investigations, in contrast to the teacher as facilitator telling them what to do. Teacher demonstrations, rushing through topics and repetition of work were responses recorded by students for ‘a bad thing about science’ in secondary school (Table 4.14).
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Results for ‘Independent Investigator’ Sub-scale

The derived sub-scale ‘Independent Investigator’ declined significantly from primary (34.98) to secondary (30.91), with these declines being present for males and females (Table 4.4) and students of different ability levels (Table 4.5). Further, secondary males scored more positively on this scale than females (Table 4.6), as did secondary higher ability students (Table 4.7). When the year six to seven interface is observed there was a significant decline from year six (35.41) to year seven (31.23) but these differences were only apparent for females and students of lesser ability (Tables 4.8 & 4.9). There were no male-female or ability differences at each of the year six or seven levels (Tables 4.10 & 4.11).

c. Results for ‘What I Really Think of Science’ Scale

These 21 items formed three sub-scales, ‘Science enthusiast’, ‘Social context’ and ‘Difficult science’ (see Table 4.3). The mean item scores for ‘Science enthusiasm’ are markedly lower than those for ‘Social context’: responses are in the negative to ambivalent range for the former, while being in the positive range for the latter. Item means for the ‘Difficult science’ scale are towards the ‘easier’ end of the scale (1) at the primary level, but some items become ambivalent (2) or towards the more difficult end of the scale (3) for secondary.

For these items there were significant primary (P) to secondary differences (S) for ‘Difficult science’: namely more agreeing that ‘we do too much science at school’ (P 1.88 to S 2.08) and ‘we do too much writing at school’ (2.00 to 2.30); for ‘Science enthusiasm’, less agreeing with ‘I like to watch science programs on TV’ (2.11 to 1.82), ‘I should like to be given a science kit as a present’ (2.21 to 1.63), ‘school science clubs are a good idea’ (2.48 to 1.59), ‘I like science more than any other school work’ (1.56 to 1.36) and ‘I often do science experiments at home’ (1.75 to 1.28); and for ‘Social context’ more agreeing with ‘TV, telephones and radio have all required science’ (2.64 to 2.79) but less agreeing with ‘science makes me think’ (2.69 to 2.44) and ‘it is easy to find out new things in science lessons’ (2.66 to 2.36) and ‘science is good for everyone’ (2.32 to 2.11).
Chapter Four

Results for the Sub-Scales of ‘What I Really Think of Science’

The following section looks at the mean scores of the sub-scales ‘Science enthusiast’, ‘Social context’ and ‘Difficult science’ derived from the ‘What I really think of science’ scales (Tables 4.3 & 4.4).

Science enthusiast

Scores for the ‘Science enthusiast’ sub-scale score were in the ambivalent (around 16) to negative range (8 to 16). From primary to secondary there was a significant decline in this sub-scale score (15.23 to 12.72) and this decline was present for males and females and students of all abilities (Tables 4.4 & 4.5); however the difference between males and females did not become significant until the secondary years, where males scored higher (Table 4.6); a similar pattern was present for students of higher ability, with secondary students scoring higher (Table 4.7). When the year six to seven interface is observed the significant declines were only present for females and students of lesser ability (Table 4.8 & 4.9). Differences between boys and girls were not present in these years (Tables 4.10). This declining trend of enthusiasm towards science from primary to secondary was supported in the short response answers where 16% of primary students wrote that science was fun or interesting to the item ‘a good thing about science’ whereas only 4.7% of secondary students responded with such a comment (Table 4.13).

Social context

No overall significant difference was found for the ‘Social context’ subscale when comparing the primary and secondary cohorts, and this was also the case for males and females and higher ability students (Table 4.4 & 4.5). However, students of lesser ability did not appreciate the social context of science as much in secondary school (Table 4.5). Further males scored higher on this scale than females at both primary and secondary level, as did secondary higher ability students (Tables 4.6 & 4.7). Across the Year six to seven divide there was an overall decrease in social context sub-scale scores, but this was only apparent for females and students of lesser ability (Tables 4.8 and 4.9). No significant differences were found between boys and girls at Years 6 and 7 (Table 4.10), but higher ability students at year seven (Table 4.11) did appreciate the social context of science more.
Difficult science

The ‘Difficult science’ subscale, although showing an overall significant increase from primary to secondary (8.91 to 9.64) did not show any differences for males and females (Table 4.4) or between them (Table 4.6), but did indicate that more lesser ability students agreed that science was difficult in the secondary years (Table 4.5), and that secondary students of higher ability thought science was less difficult than their lower ability peers (Table 4.7). When the primary/secondary interface from year six into year seven was observed, there was an overall significant difference with lesser ability students perceiving that secondary science was more difficult in year seven (Tables 4.8 & 4.9), but there were no significant differences between boys and girls or students of higher or lesser ability at either year (Tables 4.10 & 4.11). ‘Difficulty’ was a ‘bad thing about science’ mentioned by approximately 14% of both primary and secondary students; of these 41% were secondary lesser ability females (cf. 19% were secondary high ability females) and 27% were primary lesser ability females (cf. 5% primary high ability females) (Table 4.14). This is consistent with the above questionnaire data, which found that lower ability secondary students think science is more difficult than lower ability primary students and higher ability secondary students find science less difficult than their lower ability peers. Although male-female differences were not noted above, 92% of responses coded ‘difficult’ were from females and the group that was most frequently represented were lesser ability secondary females. Generally as ‘Difficult science’ mean scores increase across the year six to year seven Primary/Secondary Interface, so the ‘Science interest’ mean scores decrease (‘Difficult science’, 8.51 [P] to 10.20 [S]; ‘Science interest’, 59.11 [P] to 52.01 [S]) (Table 4.8).

d. Results for ‘Science Interest’ Composite Scale

The ‘Science interest’ composite scale was made up of a combination of ‘Independent investigator’, ‘Science enthusiast’ and ‘Social context’ scales (Tables 4.2, 4.3 & 4.4, see also Method of Analysis in Section 1). There was a significant decline in overall ‘science interest’ from primary to secondary (58.70 to 52.88) and this occurred for both males and females (Table 4.4) and between them at the secondary level (Table 4.6); also there was a decline for students of all ability levels (Table 4.5), but students of high ability scored higher at the secondary levels (Table 4.7). When looking specifically at the significant decline in interest at the year six to seven Primary/Secondary Interface, this decline is only
there for females (Table 4.8) and students of lesser ability. However no differences were found between males and females at each of these year levels but students of higher ability liked science more at both years 7, 9 and 10 (Tables 4.10 & 4.11).

**e. Gender Differences in Students of Different Abilities**

As the above results indicated that ability appeared to be a factor in determining science interest, the responses were analysed using ANOVA to determine if there were differences between high ability boys and girls at primary and secondary levels. The following findings are tentative as the cell sizes for high ability girls at the primary level were small (down to \( N=4 \)). Girls of high ability did not score significantly higher or lower than boys on any scale at the primary level, except for social context, where boys scored higher. It is also important when looking at these results to be aware that even though the classes are graded largely according to ability, there is a possibility some students in years seven to ten may be in the lower ability classes as a result of poor achievement rather than low ability and not all students who were of high ability were in the opportunity class in years five and six.

Further analyses indicated that for students, not classified as high ability, there were no significant gender differences on any of the scales at the primary level; however for student of lesser ability, at the secondary level, boys scored significantly higher than girls on all scales except for ‘Difficult science’ and ‘Liking school’, where there were no differences.

**f. Correlations Between Sub-Scales**

Overall correlations across the primary-secondary divide were determined (Table 4.12). Both males and females who perceive science as becoming more difficult tend to also appreciate the social context of science less, have less enthusiasm for the subject, less desire to be an ‘Independent investigator’ and for liking school generally.

**g. Responses to the Open-Ended Items**

The following various references involve responses to the open-ended items and have been compared with the quantitative data in the above discussion.
Chapter Four

Teacher Influence

The responses to “a bad thing about science” that related to the teacher were common with secondary school (26%) students but less common with primary students (4%) (Table 4.14). The number of sample classes in this study needs to be taken into account when looking at these results (Table 3.2).

3. Overall Summary of Results

Tables 4.8 and 4.9 provide a comparison of the derived sub-scale scores across the Years 7 to 10 as well as male and female and ability level differences across these years. Tables 4.10 and 4.11 indicate if differences are found between females and males and students of different abilities within the same year levels. Sample sizes vary considerably and the distribution of sex and ability also are not even, with higher ability students comprising about 55% of the year eight cohort, 40% of the Years 9 and 10 cohorts and 32% of the year seven cohort. As indicated earlier the more able students tended to score more highly on all scales than other students and less on the ‘Difficult Science’ sub-scale.

The following broad trends seem apparent across Years 6 to 10:

- There is no decline in ‘Liking school’ scores from year six to years 7 and scores remain stable through the secondary years; year ten shows a decline relative to the primary years (and this explains the observed overall primary-secondary difference). Boys’ scores remain stable but there is a decline for girls from years 6 to 7 but then their scores also remain stable. Students of various abilities display no interface change and scores remain stable except that lesser ability students appear to like school less in year ten than the primary years. Further, apart from females liking school more at year six level, there are no significant differences between males and females in years 7 to 10. Students of higher ability score higher in both primary and secondary, and this pattern is repeated in all secondary years except year eight.

- After a decline from year six to seven, ‘Independent investigator’ scores remain stable across years 7 to 10; this is the same for girls and students of lesser ability, except that year ten is less positively oriented towards this scale (compared to year eight). Boys and students of higher ability have stable scores from years 5 to 10.
Secondary boys do score higher than girls, but this only appears to be the case at year nine, and secondary higher ability students’ score higher than their lesser ability peers only in years 9 and 10.

- After a decline from year six to seven, ‘Science enthusiasm’ scores remain stable across years 7 to 10; this is the same for girls and students of lesser ability, except that year nine is less positively oriented towards this scale (compared to year eight). Boys and higher ability students have stable scores from years 5 to 10. However secondary boys are more enthusiastic than secondary girls, but this is only apparent in year nine. Differences in science enthusiasm between higher and lesser ability students are not apparent until the secondary years, and this appears to be mainly in years 9 and 10.

- After a decline from year six to seven, ‘Social context’ scores remain stable across years 7 to 10; this is the same for girls and students of lesser ability. Boys and higher ability students have stable scores from Years 5 to 10, except that year seven scores lower compared to years 6 and 9 depending upon the ability level (Table 4.9). However both primary and secondary boys score higher on social context than girls, but this is only present at Years 5 and 10; these differences are not present for primary students of different ability, but are there for Years 7 and 9 where higher ability students appreciate the social context more.

- After a decline from Year six to seven, ‘Science interest’ scores remain stable across Years 7 to 10; this is the same for girls and boys and students of varying ability. However secondary males score significantly higher than females; this may be due to year nine where the only significant differences were observed in the secondary years although year 5 males showed greater interest. Again higher ability students displayed more interest than their lesser ability peers at the secondary level, and this was apparent in years 7, 9 and 10.

- After an increase in ‘Difficult Science’ from year six to seven, this scale remains stable except for year nine in which there is a decrease in perceived difficulty, compared to year seven. Males and females perceive no increase in difficulty from years 7 to 10, except that year nine boys thought science was easier- it is worth noting that no differences were observed between boys and girls at any year level. Students of higher ability had stable ‘Difficult Science’ scores except that year nine perceived science to be easier, while students of lesser ability also had stable scores
except that year ten perceived the science to be more difficult than year nine. When comparing students of higher ability with those of lesser ability, higher ability secondary students perceived science to be less difficult, and this was especially the case at Years 9 and 10. As science is perceived to be more difficult in year seven compared to year six ‘Science interest’ declines.

- In Tables 4.13 and 4.14 the short response answers are categorised. The most frequent responses to ‘a good thing about science’ was ‘experiments’ or ‘practical activities’ (57.5% overall; primary [P] 45%, secondary [S] 65%) ‘learning new things’ (29.5%; P 30%; S 30%) and ‘science is fun or interesting’ (9%; P 17%; S 5%). The most frequent responses to ‘a bad thing about science were ‘writing or theory’ (42%; P 33%; S 47%); teacher related comments (18%; P 4%; S 18%); difficulty (13.6%; P 14%; S 14%); and science is boring (9.5%; P 9%; S 10%). These responses are consistent with secondary students scoring lower on the science enthusiast sub-scale as they seem to find it less fun or interesting and nearly half the sample disliked the writing involved. More secondary students indicated they liked the practical aspects of science and this is reflected in the ‘independent investigator’ subscale scores on both sides of the interface (a scale that looks at the students’ desire to work independently in science in preference to being directed by the teacher), namely the item means are higher than 3.0, although it needs to be noted that they are lower for secondary (range 3.08-4.53) than primary (range 3.29-4.76). The small number of responses related to the ‘social context’ (a scale that measures the students’ views of ‘world science’ or ‘science in society’) is probably consistent with there being no significant difference noted across the divide for this subscale and that item scores were all towards the more positive end of the scale (3.0).

In summary scores on the composite ‘Science interest’ scale and each of the ‘science’ sub-scales (except for ‘Difficult Science’) decline across the interface but remain relatively stable across years 7 to 10, while the ‘Difficult Science’ sub-scale increases across the interface and then remains relatively stable. Differences between males and females, are in general not apparent at the primary level, with some year five exceptions, but do become more obvious in the secondary years but not in relation to the perceived difficulty of science. Secondary males did score higher on several scales, but this was all at year nine
Chapter Four

level, except for the social context scale at year ten. A common pattern was that secondary students of higher ability scored higher on all scales except difficulty, where they scored lower, and that these differences were not apparent at the primary level. These differences were present in at least one scale across all secondary years except year eight.

4. An Overview of Responses of Primary and Secondary Teachers to the Results of the Attitudinal Survey

The results of the ‘attitudinal survey’ were presented at the schools involved in the project, firstly to the primary teachers, followed by a presentation to the secondary teachers; an outline of their responses is included below. The responses were taped and the tapes were transcribed.

Primary Teachers’ Responses

The teachers were asked to comment on why they thought the results revealed that students’ attitudes became less positive to science over the primary/secondary interface from year six to year seven. A number of reasons were presented, these included:

- in primary school the teachers can follow the students’ interest and make learning in science more relevant to the students, whereas in secondary school the teachers are restricted by the short sessions. A primary teacher said, “if it (the lesson) is going really well we can let it grow and take it to other fields and let them (the students) sort of be in control of where they are going, but in high school I can imagine, 40 minutes, that is the cut off point and that is it”;
- science becomes more academic in secondary school and the students are required to undertake study for exams, whereas in primary school there is less pressure on the students as the teachers might present quizzes and tests rather than exams;
- there may be a novelty factor regarding primary science, as the subject is not presented very often, and when it is presented, it might cover exciting topics, so the students may consider science a ‘treat’;
- there is a big leap from the layman’s terms in primary science to more complex language, formulae and concepts which are associated with secondary science;
teenagers have so many outside interests and become less enthusiastic, less excitable about school in secondary years and this may influence their attitudes to science; and
- the lack of practical work, large amounts of writing, and large amount of content in secondary results in boring science lessons.

One primary teacher stated that she was surprised at the results, as she believed specialist science teachers in secondary school would be passionate about this subject and endeavour to promote science to the students.

**Secondary Teachers' Responses**

A number of responses were common to both secondary and primary teachers regarding the results of the attitudinal survey, for example, the changing interests in the adolescent years, the emphasis on writing, heavy curriculum demands, less experimentation and less relevant science in secondary compared to primary school. However a number of the secondary teachers' responses were quite different to those of the primary teachers. These responses have been outlined below:

- technology today enables students to have a broad science knowledge prior to commencing secondary school and as secondary schools are in a state of decline and do not have the expensive technological equipment that the students may have seen being used by scientists, students become less interested in this subject where the equipment is dated and frequently fails to operate effectively;
- recent occupational health and safety restrictions have resulted in some extraordinary experiments and other spectacular and interesting practical experiences being limited in secondary school;
- scientists are portrayed by the media as being ‘intellectually elite’ and students who do not perceive themselves to be ‘academic’ may not apply themselves or display interest in a subject they perceive as too ‘difficult’;
- students enter secondary school with the expectation that science is going to be all experimentation though with syllabus requirements and the heavy workload in science, it does not live up to these expectations; and
• lack of professional development for science teachers to enable teachers to keep up to date with their pedagogy could impact on pedagogical practices in science.

The responses of the teachers will be helpful to inform the researcher when analysing the data and looking at strategies to address the problem of declining interest in science.

5. How the Attitudinal Survey Relates to the Case Study

When looking at the first research question “How do students attitudes to, and interest in, science change as they move from primary school into high school” it is evident from the results of this attitudinal survey that there is a significant decline in positive attitude to, and interest in, science, as students progress from primary school into secondary school. A number of factors have been revealed in this chapter and will be discussed further in chapter six. These factors address the second research question “What are the factors that affect the changes in attitude and interest towards science? However to gain a picture through the eyes of the student it is necessary to carry out an in depth study to reveal what it is that is ‘turning students off’ science in secondary school. The case study as part of this project allows students to voice their opinions about science and has enabled the researcher to obtain rich data by the use of multiple methods of data collection to address this second research question more extensively. The researcher has had the opportunity to look at science from each student’s perspective and this has assisted in identifying some of the factors that lead to interest in, a positive attitude to, motivation towards, and engagement in, science. The following chapter outlines the results of this case study.
CHAPTER FIVE

RESULTS 2: THE CASE STUDY

Introduction

This chapter outlines the results of the case study, which looked at the changes in 20 students’ attitudes to, and interest in, science over the primary/secondary interface from year six into year seven and the factors that affected these changes. All names of the participants and schools have been replaced with pseudonyms. The following list gives a brief description of each section:

1. Overall picture across the primary/secondary interface:
   Initially an overview is provided of how these students’ ‘Science interest’, as a group and as individuals, changed across the primary/secondary interface. Data are also provided as to whether changes were noted for students of different sex and ability.

2. The likes and dislikes of students and other factors that might influence students’ interests in, and attitudes towards, science across the primary/secondary interface:
   The data has been presented in two ways in this section:
   • The participant students’ voice was analysed to isolate what they liked disliked about science and why, across the primary/secondary interface: various issues emerged. Students also voiced reasons for why their interest in science might wane.
   • From observations, students’ voice and document data, other factors that may help in understanding changes across the primary/secondary interface are then noted.

3. Focus on specific students and groups of students:
   Particular students and groups of students are identified (e.g., those whose ‘Science interest’ obviously increased across the primary/secondary interface), to determine if any further understandings could be ascertained as to how these participant students’ interest could be interpreted across the primary/secondary interface.

4. Summary of the results of the case study.
Chapter Five

1. Overall picture across the primary/secondary interface

The following section is divided into sub-sections to give a general picture of the study participants’ attitudes to, and interest in, science, at the various stages across the primary/secondary interface:

a. at the end of primary school;

b. after the primary/secondary interface;

c. favourite school subjects and science career preferences across the primary/secondary interface; and

d. gender and ability differences across the primary/secondary interface

a. At the End of Primary School

At the end of year six the general picture that emerged from this study was of a group of 21 students who were generally enthusiastic and interested in ‘school science’ and ‘science in society’ (20 students remained in the study in year seven as one student left the secondary school early in year seven). Most students displayed interest in, and motivation towards, practical science. The students’ comments and classroom observations indicated that they especially enjoyed activities where they had the opportunity to design their own experiments, carry out fair tests, and suggest hypotheses. A large number of these students were motivated towards independent research involving carrying out individual experiments at home or researching topics on the internet and in encyclopaedias. Most students were interested in ‘science in society’ topics and issues particularly to do with environmental concerns, aspects of health and space exploration.

b. After Moving across the Primary/Secondary Interface

Participants as a Group

In 2004, responses to the attitudinal survey developed by Pell and Jarvis (2001), involving 264 students from the primary (years 5 to 6) and secondary (years 7 to 10) schools represented in this study, found that there was a marked and statistically significant decrease in ‘Science interest’ scores amongst students after moving from primary into secondary school (Table 5.1) (primary [P] 58.70; secondary [S] 52.88: t-test, p<0.01 (range
Table 5.1

*Differences Between Means for 2004* Total *Science interest* for Primary and Secondary Cohorts and Differences between Primary and Secondary Boys and Primary and Secondary Girls (i.e., comparing primary students' scores with secondary students' scores) *(Attitudinal Survey [Pell & Jarvis, 2001]*)

<table>
<thead>
<tr>
<th>2004</th>
<th>Primary</th>
<th>Secondary</th>
</tr>
</thead>
<tbody>
<tr>
<td>'Science interest'</td>
<td>Mean</td>
<td>N</td>
</tr>
<tr>
<td>Male and Female</td>
<td>58.70</td>
<td>92</td>
</tr>
<tr>
<td>Male</td>
<td>59.71</td>
<td>45</td>
</tr>
<tr>
<td>Female</td>
<td>57.72</td>
<td>47</td>
</tr>
</tbody>
</table>

*Note.* Significant difference between primary and secondary means two tailed t-test *p<0.01. For “Science interest” combined scales (‘Individual investigator’ + ‘Science enthusiasm’ + ‘Social context’) see Table 4.2, 4.3 & 4.4, in Chapter 4.*
25-75) (see Chapters 3 & 4 for information about this attitudinal survey and tables 4.2, 4.3 & 4.4 in Chapter 4 regarding the composite scale ‘Science interest’). This attitudinal survey was re-administered to 20% of year seven students in 2005 (the survey was administered to year seven in fourth term 2005, whereas in 2004 it was administered at the end of second term). For those students progressing from year six to year seven there was a significant decline in ‘Science interest’ for the sample of non-participant students (N=29, 19% of year seven non-participant students), that is, those not followed in this study (year six, 58.05; year seven, 53.35: t-test, p<0.05) (Table 5.2) (very similar results to those students in year seven in the attitudinal survey in 2004, Table 5.1), but no significant decline in ‘Science interest’ with the participant students (year six, 60.05; year seven, 58.35: t-test p>0.05) (Table 5.3). The year seven ‘Science interest’ scores of these two groups were compared and there was a significant difference between their scores (year seven participants 58.35; year seven non-participants 53.35: t-test p<0.05) (Table 5.4). It needs to be noted that there was no significant difference between the 20 participant students’ ‘Science interest’ scores in year six, 2004 and the 41 non-participant students who took part in the attitudinal survey (year six 2004, participants, 60.05, year six, 2004, non-participant, 58.05: t-test p>0.05) (Table 5.5). It appears from both the quantitative and qualitative data that over the primary/secondary interface the participant students, as a group, generally remained positive towards, and interested in, science.

**Participants as Individuals**

If the ‘Science interest’ scores are categorised as low (25 to 41), medium (42 to 58) and high (59 to 75), that is, a range of 16 to 17 for each category, and a difference in scores of 8 or more is interpreted as of practical significance as it is 50% of the defined range, then the following observations may be made (where the qualitative data are not consistent with variations in student ‘Science interest’ scores’ suggested by the quantitative data these are noted).

- Five participants’ ‘Science interest’ scores decreased (Alec, Tatiana, Belinda, Bree and Harry) over the primary/secondary interface (27.8% of the sample) while one increased (Daniel)(5.6%).
- 12 students’ scores (66.7%) remained relatively stable (Fig. 5.1; Table 5.6).
Table 5.2

*Differences Between Means for Total ‘Science interest’ for the Non-Participant Students*
*Year six, 2004, Primary Scores and Year seven, 2005 Secondary Scores (Attitudinal Survey [Pell & Jarvis, 2001])*

<table>
<thead>
<tr>
<th></th>
<th>Primary – Year six 2004 Non-participants</th>
<th>Secondary – Year seven 2005 Non-participants</th>
</tr>
</thead>
<tbody>
<tr>
<td>‘Science interest’</td>
<td>Mean 58.05, N 41, SD 7.33</td>
<td>Mean 53.35*, N 29, SD 9.10</td>
</tr>
</tbody>
</table>

*Note.* Significant difference between means of the non-participant students in year six 2004 and in year seven, 2005, two tailed t-test *p*<0.05. For “Science interest” combination scales (“Individual investigator” + “Science enthusiasm” + “Social context”) see Table 4.2, 4.3 & 4.4 in Chapter 4.
Table 5.3

Differences Between Means for Total 'Science interest' for the Case Study Participant Students Year six, 2004 Primary Scores and Year seven, 2005 Secondary Scores (Attitudinal Survey [Pell & Jarvis, 2001])

<table>
<thead>
<tr>
<th></th>
<th>Primary – Year six 2004 Participants</th>
<th>Secondary – Year seven 2005 Participants</th>
</tr>
</thead>
<tbody>
<tr>
<td>'Science interest'</td>
<td>Mean 60.05 N 21 SD 8.73</td>
<td>Mean 58.35 N 20 SD 7.01</td>
</tr>
</tbody>
</table>

Note. No Significant difference at the 0.05 level between means of participant students in year six and year seven, using a two tailed t-test. For “Science interest” combined scales (‘Individual investigator’ + ‘Science enthusiasm’ + ‘Social context’) see Table 4.2, 4.3 & 4.4 in Chapter 4.
### Differences Between Means for Total 'Science interest' for the Year seven, 2005 Participants Students and Year seven, 2005 Non-Participant Students Scores (Attitudinal Survey [Pell & Jarvis, 2001])

<table>
<thead>
<tr>
<th>Year seven Secondary 2005 Participant</th>
<th>Year seven Secondary 2005 Non-participants</th>
</tr>
</thead>
<tbody>
<tr>
<td>'Science interest' Mean</td>
<td>N</td>
</tr>
<tr>
<td>--------------------------</td>
<td>---</td>
</tr>
<tr>
<td>58.35</td>
<td>19</td>
</tr>
</tbody>
</table>

*Note.* Significant difference between means of Year seven participant and non-participant students, two tailed t-test *p*<0.05. For "Science interest" combination scales see (‘Individual investigator’ + ‘Science enthusiasm’ + ‘Social context’) Tables 4.2, 4.3 & 4.4 in Chapter 4.
Table 5.5

**Differences Between Means for Total 2004 'Science interest' for Year six Primary Study Participant Students and Year six Primary Non-participant Students (Attitudinal Survey [Pell & Jarvis, 2001])**

<table>
<thead>
<tr>
<th>2004</th>
<th>Year Six Study Participants</th>
<th>Year Six Non-Participants</th>
</tr>
</thead>
<tbody>
<tr>
<td>'Science interest'</td>
<td>Mean</td>
<td>N</td>
</tr>
<tr>
<td>2004</td>
<td>60.05</td>
<td>20</td>
</tr>
</tbody>
</table>

*Note.* No significant difference at the 0.05 level was found between study participant and non-participant students’ means using a two tailed t-test. For “Science interest” combined scales (‘Individual investigator’ + ‘Science enthusiasm’ + ‘Social context’) see Table 4.2, 4.3 & 4.4 in Chapter 4.
Table 5.6

*Individual Participant Students' Results for Sub-Scales of 'Independent Investigator' (9 items), 'Science Enthusiast' (8 items), Social Context' (8 items), Difficult Science' (5 items) and 'Science interest' composite scale (25 items) (attitudinal survey developed by Pelle & Jarvis, [2001]), including Sex, Ability and Class.*

<table>
<thead>
<tr>
<th>Student</th>
<th>Sx</th>
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<th>11 04</th>
<th>11 05</th>
<th>SE 04</th>
<th>SE 05</th>
<th>SC 04</th>
<th>SC 05</th>
<th>DS 04</th>
<th>DS 05</th>
<th>SI 04</th>
<th>SI 05</th>
<th>Ca 04</th>
<th>Ca 05</th>
<th>Dif 04/05</th>
<th>Cl 04</th>
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<td>6S</td>
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</tr>
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<td>M</td>
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<td>6H</td>
<td>7K</td>
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<td>H</td>
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<td>7L</td>
</tr>
<tr>
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<td>H</td>
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<td>65</td>
<td>HI</td>
<td>3</td>
<td>6H</td>
<td>7K</td>
</tr>
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<td>Leigh</td>
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<td>H</td>
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<td>15</td>
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<td>20</td>
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<td>HI</td>
<td>55</td>
<td>HI</td>
<td>7</td>
<td>6H</td>
<td>7L</td>
</tr>
</tbody>
</table>

*Note. Sx = Sex, Ab = Ability (Mi = mixed, H = High)*H (students placed into High Ability classes in secondary school, 2005), II= ‘Independent Investigator’, SE= ‘Science Enthusiast’, SC=‘Social Context’, DS= ‘Difficult Science’, SI= ‘Science interest’, Ca=Category of low (LO) (25-41), medium (MD) (42-58), or high interest (HI) (59-75), Dif= difference ‘Science Interest’ scores between 2004 and 2005, Cl=Class. *Charlotte’s attitudinal survey results appeared to be almost the same as Mayan’s. Charlotte has learning difficulties and may not have fully understood the questions when in year six, so she relied on Mayan to assist her with her answers. Her SI in 2004 was disregarded. *Tia did not complete all items on her survey in 2004; therefore any changes in her quantitative ‘Science interest’ score over the primary/secondary interface could not be determined.*
Figure 5.1

Participants as Individuals 'Science Interest' scores – Over the Primary/Secondary Interface
Chapter Five

Alec maintained a ‘high interest’ in science but perhaps lost his exceptionally keen interest over the primary/secondary interface. Belinda, Bree and Harry lost their ‘high interest in science’ and Tatiana’s interest remained in the ‘medium’ range. Daniel’s qualitative data supports an increase in interest in science. Although not included in the statistics above, Tia’s qualitative data suggested an increase in ‘Science interest’ although her change in ‘Science interest’ score could not be calculated, as her survey was incomplete in year six. These students are discussed further below.

Hence, although as a group these participants’ ‘Science interest’ scores did not differ significantly, an analysis of their individual scores does suggest that ‘practical’ differences from the data described above, did occur with about a third of the sample, and that the qualitative data was, in general, consistent with these individual differences.

c. Favourite School Subjects and Science Career Preference across the Primary/Secondary Interface

This following section describes differences across the primary/secondary interface related to:

i. favourite subjects; and

ii. careers.

(i). Favourite Subjects

Over 50% of the students said that science was one of their favourite subjects in year seven, a similar percentage to that found in year six (Table 5.7). Four (of 8) mixed ability and seven (of 12) high ability students listed science as one of their favourite subjects in year seven with two students clearly differentiating between practical science as opposed to science theory. Ability did not appear to be an obvious factor here. These preferences are consistent with a majority of students retaining an interest in science and 14 (of 18) year seven students recording high ‘Science interest’ scores in year seven.

Other competing subjects for the students’ interest

Seven of the 11 students in year seven who listed science as one of their favourite subjects also included maths. Only one student listed maths amongst his favourite
## Table 5.7

**Individual Participant Student Responses to favourite subjects at school**

<table>
<thead>
<tr>
<th>Name</th>
<th>Ability</th>
<th>Science Primary Y6</th>
<th>Other subjects Y6</th>
<th>Science Secondary Y7</th>
<th>Other subjects Y7</th>
</tr>
</thead>
<tbody>
<tr>
<td>Roxy</td>
<td>Mixed</td>
<td>English/art</td>
<td>Other subjects</td>
<td>Science</td>
<td>English/art/PE</td>
</tr>
<tr>
<td>Mayan</td>
<td>Mixed</td>
<td>Art</td>
<td>Other subjects</td>
<td>Y7</td>
<td>Art/PE</td>
</tr>
<tr>
<td>Charlotte</td>
<td>Mixed</td>
<td>English/maths</td>
<td>Science 2nd</td>
<td>Maths 1st art 3rd</td>
<td>Maths/Science</td>
</tr>
<tr>
<td>Bree</td>
<td>Mixed</td>
<td>Art, English and PE</td>
<td>Other subjects</td>
<td>Y7</td>
<td>Art/Sewing/PE</td>
</tr>
<tr>
<td>Clay</td>
<td>Mixed</td>
<td>Science 2nd</td>
<td>Story writing/</td>
<td>Science 2nd</td>
<td>Maths/PE</td>
</tr>
<tr>
<td>Jake</td>
<td>Mixed</td>
<td>-</td>
<td>Reading</td>
<td>(when practical)</td>
<td>Wood technology</td>
</tr>
<tr>
<td>Matt</td>
<td>Mixed</td>
<td>Science (3rd)</td>
<td>Maths/sport</td>
<td>Science (1st)</td>
<td>PDHPE/English</td>
</tr>
<tr>
<td>Daniel</td>
<td>Mixed</td>
<td>Maths/sport/</td>
<td>Science (2nd)</td>
<td>Maths/PE</td>
<td>English</td>
</tr>
<tr>
<td>Harry</td>
<td>Mixed</td>
<td>Maths/reading</td>
<td>Other subjects</td>
<td>Y7</td>
<td>History/maths</td>
</tr>
<tr>
<td>Bob</td>
<td><em>High</em></td>
<td>Sport</td>
<td>Other subjects</td>
<td>Y7</td>
<td>Wood technology</td>
</tr>
<tr>
<td>Ethen</td>
<td>High</td>
<td>Science equal</td>
<td>Maths</td>
<td>Science (1st)</td>
<td>Computer technology/</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>industrial arts/visual</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>technology/home economics</td>
</tr>
<tr>
<td>Alec</td>
<td>High</td>
<td></td>
<td>Science (1st)</td>
<td>Music/PE</td>
<td></td>
</tr>
<tr>
<td>Tyson</td>
<td>High</td>
<td>Sometimes science</td>
<td>Maths/art</td>
<td>Other subjects</td>
<td>Home economics</td>
</tr>
<tr>
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<td></td>
<td></td>
<td></td>
<td>Y7</td>
<td>computer technology</td>
</tr>
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<td>Martin</td>
<td>High</td>
<td>Science (1st)</td>
<td>Maths/spelling</td>
<td>Science (2nd)</td>
<td>Industrial arts/math</td>
</tr>
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<td>Belinda</td>
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<td>Science (1st)</td>
<td>Maths</td>
<td>Science – (when practical)</td>
<td>Maths</td>
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<td>Tia</td>
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<td>Science (2nd)</td>
<td>English/art</td>
<td>Science (3rd)</td>
<td>Art/industrial arts/English</td>
</tr>
<tr>
<td>Cara</td>
<td>High</td>
<td>Science (2nd)</td>
<td>English</td>
<td>Art</td>
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</tr>
<tr>
<td>Leigh</td>
<td>High</td>
<td>English/art</td>
<td>“Science is alright but not that fun”</td>
<td>Cooking, woodwork and maths</td>
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<td>Alana</td>
<td><em>High</em></td>
<td>Science (3rd)</td>
<td>English/story</td>
<td>Wood technology/</td>
<td></td>
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<td></td>
<td></td>
<td>writing</td>
<td>English/PE</td>
<td></td>
</tr>
<tr>
<td>Tatiana</td>
<td><em>High</em></td>
<td>Music/English</td>
<td>Other subjects</td>
<td>Music/</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>drama</td>
<td></td>
<td>Language</td>
<td></td>
</tr>
<tr>
<td>Anne</td>
<td><em>High</em></td>
<td>Maths/poetry</td>
<td>Science (2nd)</td>
<td>Maths/English</td>
<td></td>
</tr>
</tbody>
</table>

Note: *High = Students placed in high ability classes in year seven (secondary), 2005.*
subjects and did not include science. Six students included English as one of their favourite subjects and four of these also included science. The technology subjects which are a novelty to the students in year seven, including wood and metal technology, and home economics, are commonly listed amongst the students’ favourite subjects in year seven (Table 5.7).

**Careers**

There was a shift in preferences for science related careers across the primary/secondary interface: 14 students wished to follow careers involving science in year six as compared to seven students in year seven (Table 5.8).

In summary a majority of these participant students still had a high interest in science in year seven but other subjects were also competing for their interest and could influence their career preferences.

**d. Gender and Ability Differences Across the Primary/Secondary Interface**

**As a group**

There was no significant difference between the males’ and females’ ‘Science interest’ scores in year six or year seven (boys 60.44; girls 56.64, t-test, Table 5.9).

When considered *individually*, the following observations were noted:

**More Interest in Secondary Science**

**Gender**

- Eleven (of 20) students in year seven, when asked to compare secondary school science and primary school science, stated that they preferred secondary science to primary science: four (of 10) females and seven (of 10) males (some students made comparisons without stating their preference for primary or secondary science) (Table 5.10).
- One male student’s ‘Science interest’ score [Daniel] became markedly higher over the primary/secondary interface (Table 5.6).
Table 5.8

*Individual Responses of Participant Students to ‘What I want to do when I Finish School’ Classified by Science Related and Other*

<table>
<thead>
<tr>
<th>Student</th>
<th>Ability</th>
<th>Yr 6 - Science Related</th>
<th>Yr 6 - Other</th>
<th>Yr 7 - Science Related</th>
<th>Yr 7 - Other</th>
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<td>Mixed</td>
<td>Vet</td>
<td>Lawyer</td>
<td></td>
<td>Lawyer</td>
</tr>
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<td>Mayan</td>
<td>Mixed</td>
<td>Vet/vet nurse</td>
<td>-</td>
<td>-</td>
<td>-</td>
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<tr>
<td>Charlotte</td>
<td>Mixed</td>
<td>Teacher</td>
<td>Nurse (3rd)</td>
<td>Preschool teacher</td>
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</tr>
<tr>
<td>Bree</td>
<td>Mixed</td>
<td>Find cancer cure</td>
<td>Drama and art</td>
<td></td>
<td></td>
</tr>
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<td>Clay</td>
<td>Mixed</td>
<td>Professional</td>
<td>Professional Rugby Union player</td>
<td>Professional Rugby Union player</td>
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</tr>
<tr>
<td>Jake</td>
<td>Mixed</td>
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<td>Do not know</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Matt</td>
<td>Mixed</td>
<td>Movie maker/band</td>
<td>Policeman</td>
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<td>Do not know</td>
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<td></td>
</tr>
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<td>Do not know</td>
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<td></td>
</tr>
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<td>Alana</td>
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<td>Actor</td>
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</tr>
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<td>Tatiana</td>
<td>*High</td>
<td>Vet/Doctor/Teacher</td>
<td>Lawyer</td>
<td>Working with animals (2nd)</td>
<td>Lawyer (1st), or working with music</td>
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<td>Pre-school teacher or Nanny</td>
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<td>Do not know</td>
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<td>Alec</td>
<td>High</td>
<td>Vet</td>
<td>Vet</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tyson</td>
<td>High</td>
<td>Lawyer</td>
<td>Lawyer</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Martin</td>
<td>High</td>
<td>Vet</td>
<td>Vet (probably)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Belinda</td>
<td>High</td>
<td>Accountant or lawyer</td>
<td>Accountant or lawyer</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tia</td>
<td>High</td>
<td>Work with animals</td>
<td>Vet</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cara</td>
<td>High</td>
<td>Find a cure for cancer</td>
<td>Find a cure for cancer</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Leigh</td>
<td>High</td>
<td>Breed horses</td>
<td>Do not know</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Frequency</td>
<td>14</td>
<td>5</td>
<td>7</td>
<td>10</td>
<td></td>
</tr>
</tbody>
</table>

Note: *High = Students placed in high ability classes in year seven (secondary), 2005.*
Table 5.9

Differences Between Means for Total “Science interest” for Year seven Secondary Boys and Year seven Secondary Girls 2005 for Case Study Participant Students and Non-participant Students (Attitudinal Survey [Pell & Jarvis, 2001])

<table>
<thead>
<tr>
<th>2005</th>
<th>Males</th>
<th></th>
<th>Females</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>N</td>
<td>SD</td>
<td>Mean</td>
</tr>
<tr>
<td>Total Participant and Non-Participant</td>
<td>54.48</td>
<td>23</td>
<td>8.30</td>
<td>56.19</td>
</tr>
<tr>
<td>Participant Only</td>
<td>60.44</td>
<td>9</td>
<td>6.77</td>
<td>56.64</td>
</tr>
</tbody>
</table>

Note. No Significant difference at the 0.05 level between means of year seven males and year seven females, (participant and non-participant) using a two tailed t-test. For ‘Science interest’ combined scales see Tables 4.2, 4.3 & 4.4 in Chapter 4.
Table 5.10

**Frequency of Participant Students’ Responses when Comparing Science in Primary School with Science in Secondary School, Classified by Sex, Ability and Class**

<table>
<thead>
<tr>
<th>Response</th>
<th>Sex</th>
<th>Ability</th>
<th>Class</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Secondary school science is better than primary school</td>
<td>Female</td>
<td>High</td>
<td>7K</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>High</td>
<td>7L</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>Mixed</td>
<td>7R</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Male</td>
<td>High</td>
<td>7L</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Male</td>
<td>Mixed</td>
<td>7H</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Male</td>
<td>Mixed</td>
<td>7S</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Male</td>
<td>Mixed</td>
<td>7P</td>
<td>1</td>
</tr>
<tr>
<td>I preferred science in primary school</td>
<td>Female</td>
<td>High</td>
<td>7K</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>Mixed</td>
<td>7P</td>
<td>1</td>
</tr>
<tr>
<td>Would like more independent research in secondary</td>
<td>Male</td>
<td>High</td>
<td>7K</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Male</td>
<td>High</td>
<td>7L</td>
<td>2</td>
</tr>
<tr>
<td>There was more student-centred learning in primary</td>
<td>Female</td>
<td>High</td>
<td>7K</td>
<td>4</td>
</tr>
<tr>
<td>(independent investigating and exploring)</td>
<td>Female</td>
<td>Mixed</td>
<td>7R</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>Mixed</td>
<td>7P</td>
<td>1</td>
</tr>
</tbody>
</table>
Ability

- When considering ability and how that related to students’ preference for secondary science the numbers of high ability and mixed ability students were similar. Eleven (of 20) students preferred secondary science to primary science, five of these students were high ability (3 female and 2 male) and six were mixed ability (one female and five male).
- Daniel whose, ‘Science interest’ score became markedly higher over the primary/secondary interface, was a mixed ability student.

Less Interest in Secondary Science

Gender

- Three female students (no males) said they preferred science in primary school and all three students were from classes in year six (6R, 6T & 6S) where practical science was presented, in which the students were encouraged to investigate, carry out fair tests and hypothesize (Table 5.10).
- Two male and three female students had ‘Science interest’ scores that decreased over the primary/secondary interface (Table 5.6).

Ability

- Two of the three students who said they preferred science in primary were high ability students (2 [of 7] high ability females) and one was a mixed ability student (one [of 3] mixed ability females).
- Of the students who had ‘Science interest’ scores that decreased over the primary/secondary interface, three were high ability students (1 male and 2 females) and two were mixed ability student (1 male and 1 female) (Table 5.6).

These data suggest that secondary science may be of equal or more interest to these participant males than females. High ability males appear to retain or increase their interest more across the primary/secondary interface, while there are mixed perceptions expressed by high ability females. There is the suggestion that pedagogical differences may have also been an influence.
Chapter Five

2. The Likes and Dislikes of Students and other Factors that Might Influence Students’ Interests in, and Attitudes Towards, Science Across the Primary/Secondary Interface

a. Students’ voice across the Primary/Secondary Interface: Their likes and Dislikes

Why did some students retain or lose interest across the primary/secondary interface? These students voiced several reasons; others could be hypothesised from a combination of observational and document sources. The following sections look at:

i. retaining interest in science across the primary/secondary interface (the participant students’ voice); and

ii. losing interest in science across the primary/secondary interface (the participant students’ voice).

(i). Retaining Interest in Science Across the Primary/Secondary Interface (the Participant Students’ Voice)

According to the data collected during interviews, surveys and observations, the students’ interest appeared to be retained by science activities that were ‘practical’, particularly those activities that involved the use of Bunsen burners, the microscope, and experiments involving chemical reactions. Learning new things, particular topics, encouragement of student discussion, and questioning during science lessons may also retain interest.

Practical Science

In both years six and seven, all participant students stated that they liked the practical aspects of science when asked ‘what they like about science’ during interviews and focus groups or in written survey responses. This love of practical science was supported by the responses to the open questions in the attitudinal survey administered in 2004, where 57.5% of all students (across years 5 to 10) stated that practical science was a ‘good thing about science’ (See Chapter 4, Table 4.13). When asked why they liked practical aspects:

- Ninety five percent (20 [of 21]) of year six participant students replied with comments such as ‘hands on’ science was ‘fun’, ‘interesting’, ‘fascinating’ or ‘cool’.
In year seven, 70% (14 [of 20]) of these students stated the same reasons, but other reasons became more common such as “better than writing” (45%; 9 [of 20]) or “learning more by doing” (15%; 3 [of 20]).

Thirty five percent of students (5 [of 10] females and 2 [of 10] males) described how experiments make it easier to understand ‘things’ in science (conceptual ideas).

During a focus group in year six, Leigh, a high ability student said, “Why don’t they just show you an experiment and have to make you figure it out for yourself? If you see it you understand it more. If they (the other students) are having fun they will pay attention more”.

Learning New Things

When looking at various aspects of science enjoyed by students, ‘learning new things’ was a common response amongst the high ability students (3 [of 5] males and four [of 7] females) and three mixed ability female students (of 4) in year six. In year seven this response was noted from two (of 5) high ability males, two (of 7) high ability females and all mixed ability females. This comment was more popular with females in general and high ability males. No mixed ability males, either in year six or year seven reported, “learning new things” as an aspect of science that they enjoyed (Table 5.11).

Perceived Interest in Particular Science Topics

There were no direct questions relating to preferred topics so the data in this area was limited. However the following is an overview of general responses during interviews and focus groups or those included in survey questions, relating to science topics.

Natural science

Natural Science particularly to do with plants and animals, was a popular topic with high ability students in year six (3 [of 4] males and two [of 4] females from 6H) (Table 5.11). The students from 6H took part in individual projects where they researched animals and plants with the use of the Internet and books. A number of these students stated that they wanted to follow a career in veterinary science (Table 5.8). In year seven all classes covered topics involving animals and plants. Three year seven students (one [of 5] high ability male, one [of 7] high ability female, one [of 5] mixed ability male, and one [of 3] mixed ability female) stated their enjoyment of these topics. However Daniel commented...
Table 5.11

Frequency of Participant Students’ Responses to “What I like about science”, Classified by Sex, Ability and Class

<table>
<thead>
<tr>
<th>Response</th>
<th>Sex</th>
<th>Ability</th>
<th>Class</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Learning new things</td>
<td>Female</td>
<td>Mixed</td>
<td>6R</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>Mixed</td>
<td>6T</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>Mixed</td>
<td>7S</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>Mixed</td>
<td>7L</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>High</td>
<td>6H</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>High</td>
<td>6S</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>High</td>
<td>7K</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Male</td>
<td>High</td>
<td>6H</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Male</td>
<td>High</td>
<td>7L</td>
<td>2</td>
</tr>
<tr>
<td>Natural Science (individual projects, researching on computers)</td>
<td>Female</td>
<td>High</td>
<td>6H</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Male</td>
<td>High</td>
<td>6H</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Male</td>
<td>Mixed</td>
<td>7H</td>
<td>1</td>
</tr>
<tr>
<td>Natural Science topics (biology)</td>
<td>Female</td>
<td>Mixed</td>
<td>7S</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>High</td>
<td>7K</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Male</td>
<td>High</td>
<td>7L</td>
<td>1</td>
</tr>
<tr>
<td>Electrical Circuits</td>
<td>Female</td>
<td>Mixed</td>
<td>6T</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>Mixed</td>
<td>6S</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Male</td>
<td>Mixed</td>
<td>6T</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Male</td>
<td>High</td>
<td>6H</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>Mixed</td>
<td>7P</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>High</td>
<td>7L</td>
<td>1</td>
</tr>
<tr>
<td>Experiments involving Bunsen burners, fire or explosions</td>
<td>Female</td>
<td>Mixed</td>
<td>7P</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>High</td>
<td>7K</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Male</td>
<td>Mixed</td>
<td>7S</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Male</td>
<td>Mixed</td>
<td>7P</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Male</td>
<td>High</td>
<td>7K</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Male</td>
<td>High</td>
<td>7L</td>
<td>2</td>
</tr>
</tbody>
</table>
in year seven, at the lack of practical activities and the large amount of ‘copying’ notes during topics on plants and animals. Three mixed ability students (one [of 5] male and two [of 3] females) enjoyed an individual homework project involving researching animals with the use of the computer or books and other resources (Table 5.12).

Students voice on how to improve natural science

Tia, Leigh (both in 7L) and Bob (7K) thought it would be a good idea to make more use of the school grounds when working on topics to do with living things as this topic involved mainly theory such as classification and few practical lessons. Bree found using dichotomous keys during ‘living things’ topics difficult (Table 5.13).

Electricity topics

Experimenting with electricity was mentioned as an interesting activity enjoyed by both male and female students in year six (one [of 5] mixed ability male, two [of 4] mixed ability females, one [of 5] high ability male and one [of 7] high ability female). In year seven the electricity topic was enjoyed by two students, one [of 3] mixed ability female, and one [of 7] high ability female. However Tatiana found her test in electricity difficult in primary school (Table 5.11).

Fire and Explosions

In year seven more males than females made reference to the use of Bunsen burners and experiments involving fire, as an enjoyable aspect of science. Five males (3 [of 5] mixed ability, 2 [of 5] high ability) and four females (1 [of 3] mixed ability, 3 [of 7] high ability), reported their fascination for these activities (5.14). Three students said that they liked explosions in science, one (of 3) mixed ability female and two (of 5) high ability males (Table 5.12).

Physic topics were disliked (perhaps due to difficulty).

All students appeared to generally like all topics in both year six and year seven apart from Martin and Tyson who said they did not enjoy aspects of physics such as light and machines as they found these aspects of science difficult to understand. Martin also stated that he did not like mechanics in physics in year seven (Table 5.13).
Table 5.12

*Frequency of Participant Students' interest displayed towards certain subjects or the use of equipment, Classified by Sex, Ability and Class*

<table>
<thead>
<tr>
<th>Response</th>
<th>Sex</th>
<th>Ability</th>
<th>Class</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Natural science</td>
<td>Female</td>
<td>High</td>
<td>6H</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Male</td>
<td>High</td>
<td>6H</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>High</td>
<td>7K</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>Mixed</td>
<td>7P</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>Mixed</td>
<td>7S</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Male</td>
<td>High</td>
<td>7L</td>
<td>1</td>
</tr>
<tr>
<td>Individual research involving living things</td>
<td>Female</td>
<td>Mixed</td>
<td>6T</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>Mixed</td>
<td>7S</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Male</td>
<td>Mixed</td>
<td>7H</td>
<td>1</td>
</tr>
<tr>
<td>Astronomy</td>
<td>Female</td>
<td>High</td>
<td>7S</td>
<td>1</td>
</tr>
<tr>
<td>Electricity</td>
<td>Female</td>
<td>Mixed</td>
<td>6T</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>High</td>
<td>6S</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Male</td>
<td>Mixed</td>
<td>6T</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Male</td>
<td>High</td>
<td>6H</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>Mixed</td>
<td>7P</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>High</td>
<td>7K</td>
<td>1</td>
</tr>
<tr>
<td>Fire (including the use of Bunsen burners)</td>
<td>Female</td>
<td>Mixed</td>
<td>7P</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>High</td>
<td>7K</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>High</td>
<td>7L</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Male</td>
<td>Mixed</td>
<td>7P</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Male</td>
<td>Mixed</td>
<td>7H</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Male</td>
<td>High</td>
<td>7L</td>
<td>2</td>
</tr>
<tr>
<td>Explosions</td>
<td>Female</td>
<td>High</td>
<td>7S</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Male</td>
<td>High</td>
<td>7K</td>
<td>2</td>
</tr>
<tr>
<td>Microscopes</td>
<td>Male</td>
<td>Mixed</td>
<td>7S</td>
<td>1</td>
</tr>
<tr>
<td>Magnets</td>
<td>Female</td>
<td>Mixed</td>
<td>7P</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>High</td>
<td>7K</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Male</td>
<td>Mixed</td>
<td>7P</td>
<td>1</td>
</tr>
<tr>
<td>Videos/TV (watching)</td>
<td>Female</td>
<td>Mixed</td>
<td>7R</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>Mixed</td>
<td>7P</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>High</td>
<td>7K</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Male</td>
<td>Mixed</td>
<td>7H</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Male</td>
<td>High</td>
<td>7L</td>
<td>1</td>
</tr>
<tr>
<td>Video making</td>
<td>Female</td>
<td>Mixed</td>
<td>6R</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>Mixed</td>
<td>6T</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Male</td>
<td>High</td>
<td>6H</td>
<td>1</td>
</tr>
<tr>
<td>Using computers or laptops in science for</td>
<td>Male</td>
<td>Mixed</td>
<td>6T</td>
<td>1</td>
</tr>
<tr>
<td>research or instead of writing including</td>
<td>Female</td>
<td>Mixed</td>
<td>7S</td>
<td>1</td>
</tr>
<tr>
<td>power point presentations, interactive CD's</td>
<td>Male</td>
<td>Mixed</td>
<td>7H</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Male</td>
<td>High</td>
<td>7L</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Male</td>
<td>High</td>
<td>7K</td>
<td>2</td>
</tr>
</tbody>
</table>
Table 5.13

*Frequency of Participant Students’ Responses to “What I find difficult in science”, Classified by Sex, Ability and Class*

<table>
<thead>
<tr>
<th>Response</th>
<th>Sex</th>
<th>Ability</th>
<th>Class</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Writing</td>
<td>Male</td>
<td>Mixed</td>
<td>6T</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Male</td>
<td>High</td>
<td>7K</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Male</td>
<td>Mixed</td>
<td>7R</td>
<td>2</td>
</tr>
<tr>
<td>Physics</td>
<td>Male</td>
<td>High</td>
<td>6H</td>
<td>1</td>
</tr>
<tr>
<td>Physics (mechanics)</td>
<td>Male</td>
<td>High</td>
<td>6H</td>
<td>1</td>
</tr>
<tr>
<td>Physics (electricity)</td>
<td>Female</td>
<td>High</td>
<td>6S</td>
<td>1</td>
</tr>
<tr>
<td>Large amount to remember</td>
<td>Female</td>
<td>High</td>
<td>7K</td>
<td>1</td>
</tr>
<tr>
<td>Stuff you don’t know</td>
<td>Female</td>
<td>Mixed</td>
<td>6T</td>
<td>1</td>
</tr>
<tr>
<td>Need more explanations</td>
<td>Female</td>
<td>Mixed</td>
<td>6T</td>
<td>1</td>
</tr>
<tr>
<td>Light a match</td>
<td>Female</td>
<td>Mixed</td>
<td>7P</td>
<td>1</td>
</tr>
<tr>
<td>Dichotomous Keys</td>
<td>Female</td>
<td>Mixed</td>
<td>7R</td>
<td>1</td>
</tr>
<tr>
<td>Difficult scientific terms</td>
<td>Female</td>
<td>High</td>
<td>7K</td>
<td>1</td>
</tr>
<tr>
<td>Finding information on the Internet</td>
<td>Female</td>
<td>High</td>
<td>6H</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Male</td>
<td>High</td>
<td>6H</td>
<td>2</td>
</tr>
<tr>
<td>Measuring</td>
<td>Female</td>
<td>High</td>
<td>6S</td>
<td>1</td>
</tr>
<tr>
<td>Remembering all the ways to separate mixtures</td>
<td>Female</td>
<td>High</td>
<td>7K</td>
<td>1</td>
</tr>
<tr>
<td>Nothing</td>
<td>Female</td>
<td>Mixed</td>
<td>6R</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>High</td>
<td>6H</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Male</td>
<td>High</td>
<td>6S</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Male</td>
<td>Mixed</td>
<td>7S</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>High</td>
<td>7K</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>High</td>
<td>7L</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Male</td>
<td>High</td>
<td>7L</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Male</td>
<td>High</td>
<td>7K</td>
<td>2</td>
</tr>
</tbody>
</table>
Student Questioning and Discussion

During the interviews with teachers it was interesting to hear about the students who enjoyed questioning and discussing aspects of science. Martin's teachers, both in 6H and 7L, mentioned his exceptional knowledge of living things. Martin's teacher in year six said how Martin loved to discuss environmental matters with his classmates and related newly acquired knowledge to other situations. For example, after learning about the warming of the ocean he wondered how this would affect the Krill population and therefore the whale population. Martin's 'Science interest' score remained stable in the high range across the primary/secondary interface.

Year seven teachers identified a number of both high and mixed ability students who liked to discuss and question aspects of science. Martin, Alec, Alana, Belinda, Tia, Leigh, Bob, and Ethen were high ability students and Daniel and Roxy were mixed ability students; further in year seven all except Belinda had high 'Science interest' scores. They were distributed over three of the year seven classes (7K, 4 students; 7L, 3 students; and two from 7S). These teachers obviously had taken part in discussions with, or had observed these students having discussions, to draw these conclusions but it was difficult to ascertain how much time and encouragement was allocated to allow students to discuss and debate aspects of science in year seven. During observations in the year seven classes there were times when the teachers asked the students to answer questions relating to the topic but in depth discussion involving the students was not observed by the researcher.

(ii). Losing Interest in Science across the Primary/Secondary Interface (the participant students’ voice)

Similarly these students voiced reasons for why their interest in science might wane. These included:

- excessive writing and copying of science notes;
- lack of independent research and student-centred learning in science (as opposed to teacher-centred learning);
- increase in science difficulty;
- decrease in practical science in some classes;
• decrease of Information Communication Technology (ICT) in secondary school;
  and
• lack of relevance of school science (in relation to science in society).

The following section discusses these reasons that may have led to a loss of interest in science.

**Excessive Writing and Copying of Science Notes**

The interview, survey and focus group data indicated that in year six 71% (15 [of 21]) of students stated that they disliked writing in science; in year seven this was the case with all students (100%). This dislike of writing was also supported by secondary students' (Years 7 to 10) responses to the attitudinal survey where 47% responded with ‘writing’ as a ‘bad thing about science’ (Table 4.14, Chapter 4). It was interesting to note that Alana and Clay both stated that writing stories was their favourite activity in year six, and seven students (6 female; 1 male) listed English, which involves a large amount of writing, as their favourite subject in primary school (Table 5.7). English continued to rate amongst six students’ (4 female; 2 male) favourite subjects in year seven (Table 5.7).

**Student voice on how to reduce excessive writing and copying in science**

In a participant focus group interview, the students were asked how they would plan their school science if they were given the opportunity: Bob discussed how it would be better to have printed notes rather than written notes and that it is easier to understand aspects of science by participating in an experiment rather than merely writing notes about a topic. The use of computer for the writing of notes was also considered as an alternative to writing in books by six students (1 female; 5 male) and five out of the six students were in year seven (Table 5.12).

**Lack of Independent Research and Student-Centred Learning**

Alec, Ethen and Martin from 6H in 2004, all expressed their disappointment in the lack of independent research in secondary school. Most of the students in 6H appeared to enjoy participating in: independent research in primary school; carrying out investigations at home; and independent research on the Internet or from encyclopaedias and books. In year
seven, Martin stated that he would like to be able to investigate aspects of science himself and compare his results with others.

Six female students (3 from 7K; in primary from 6R, 6S & 6T) voiced their disappointment in the lack of student-centred learning in secondary school, where they did not, for example, have the opportunity to explore or investigate and carry out fair tests. They stated how their science was more student-centred in primary school as they had the opportunity to hypothesize and test their predictions. During a focus group in year seven:

- Bob and Alec (from 7K) and Bree (7R) all voiced their dislike of being told what is going to happen before they do an experiment; they said they would rather plan the experiment themselves and determine what will happen. Bree said, “I’d rather discover” when doing an experiment; “when the teacher tells you what is going to happen first it takes the excitement away”.

Being told the results of the experiment before conducting it was also recorded by secondary students to a response to “a bad thing about science” in the attitudinal survey in 2004.

From observations and individual interviews:

- Bree appeared to maintain her ‘Science interest’ in year seven, and she stated that she was pleasantly surprised by the science in secondary school. However, her ‘Science interest’ score reduced by 11 points over the primary/secondary interface (61 to 50), particularly the ‘Science enthusiasm’ component of the ‘Science interest’ score. This reduction possibly reflected her disappointment in the lack of student-centred investigating in secondary school, and when in year seven she reflected on how much she had enjoyed her investigations in primary school. However when looking at Bree’s ‘Independent investigator’ scores in her attitudinal survey they had remained constant over the primary/secondary interface (Table 5.6). Bree appeared to be highly motivated during her year six investigations and engaged with her learning. In year seven she also appeared to motivated to do her science work and appeared to be engaged with her learning although it most likely was engagement with ‘peripheral things’ (Pugh, 2004) and how much she related her learning to matters outside of the classroom was not known.
Chapter Five

Increasing Difficulty of Science

When looking at the ‘Difficult science’ scores of participant students as a group across the primary/secondary interface there was a significant difference (P 8.7; S 10.4, p<0.05) (Table 5.14). It is possible that students who found science to be more difficult in year seven became less interested in the subject. This was the case with the 264 students who completed the attitudinal survey, administered in 2004, where an overall medium negative correlation between the sub-scales, ‘Difficult science’ scores and ‘Science interest’ was found (Table 4.12, Chapter 4). The ‘Difficult science’ sub scores of the participant students in year seven, from the responses in the attitudinal survey revealed that 11 (of 18) (61%) students’ scores for ‘Difficult science’ increased over the primary/secondary interface (Table 4.8, Chapter 4) and of these:

- seven (of 12) were high ability students, one (of 4) was from 7L and six (of 7) were from 7K; and
- four (of 7) (57%) were mixed ability students (1 [of 3] from 7S, 1 [of 1] from 7R and 2 [of 2] from 7H).

Reasons for increases in perceived difficulties in science

When asked what they found difficult in science, the responses of students in year six included:

- physics (such as electricity and mechanics) (3), writing (1), getting information (5), lack of teacher explanation (1), scientific terms (1) and learning things you don’t know (1), (and nothing [5]) (Table 5.13).

In year seven the aspects that students found difficult included:

- scientific terms (1), writing (2), physics such as mechanics (1), dichotomous keys (1) and a large amount to remember (1) (and nothing [8]) (Table 5.13).

Martin and Tyson indicated that they disliked some physics topics because they were difficult (see ‘perceived interest in particular science topics’ above). A number of students found difficulty with other topics: Tatiana found electricity difficult in year six and Roxy, also in year six, had difficulty with aspects of electric circuits such as understanding how to connect a light globe in a circuit. Tatiana had difficulty remembering large amounts of information while working with mixtures and compounds in year seven.
Table 5.14

Differences Between Means for ‘Difficult Science’ Sub-scores for the Participant Students in Year six, Primary School, 2004 and Year seven Secondary School, 2005 [Pell & Jarvis, 2001]

<table>
<thead>
<tr>
<th>‘Difficult Science’</th>
<th>Mean</th>
<th>N</th>
<th>SD</th>
<th>Mean</th>
<th>N</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Year six</td>
<td></td>
<td></td>
<td></td>
<td>Year seven</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Primary</td>
<td></td>
<td></td>
<td></td>
<td>Secondary –</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2004 Participants</td>
<td></td>
<td></td>
<td></td>
<td>2005 Participants</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8.70</td>
<td>20</td>
<td>2.25</td>
<td>10.40*</td>
<td>20</td>
<td>2.06</td>
<td></td>
</tr>
</tbody>
</table>

Note. Significant difference between means of participant students in Year six, 2004 and Year seven, 2005 two tailed t-test *p<0.05. For ‘Difficult Science’ sub-scales see Table 4.3 in Chapter 4.
Decrease in Practical Science in Some Classes

A number of students complained that they were not doing enough practical work in science; this appeared to be related to specific classes and is discussed further under ‘the impact of specific classroom environments’.

Decreasing Use of Audio Visual Aids and Information and Communication Technology (ICT) in Science

There were a number of references to ICT particularly in regard to alternatives to writing in science (as mentioned above under ‘excessive writing and copying of science notes’). Several students suggested the use of laptops or computers in science lessons. Programs such as ‘power point presentations’ to record information in science were enjoyed by students in primary school and mentioned as an alternative to writing in science books. It was suggested during focus groups in year six that digital cameras or video cameras could be used to record information such as the results of investigations in science. Bree added during a focus group discussion regarding taking notes during investigations, “you could get a digital camera and take photos of each day and stick it into a book, or we could make a video like a diary of each day”.

The majority of students from the OC class enjoyed independent research on the Internet in primary school science. However three (of 8 [in the OC class]) high ability students made reference to their frustration in not being able to retrieve information on particular topics. Tyson particularly liked independent research on the computer and excelled with his creation of power point presentations with science themes in year six. One of Tyson’s favourite subjects in secondary school was computer technology. Tyson appeared to be generally distracted and was not engaged in the science activities when observations were taking place in the classroom later in year seven.

Seven (of 20) students stated that videos or science shows were enjoyed in science classes in year seven. Two high ability students (from 7K), during a focus group, were complaining about the extensive use of text books in their science class and suggested that observing interactive Compact Disks (CDs) and printing out the information would be preferable to copying from textbooks. It was obvious from classroom observations and
interview data that the use of ICT was noticeably less frequent in year seven compared to 6H in the primary school.

Relevance of ‘Science in Society’ and of ‘School Science’

In year six a number of comments from high ability students indicated an appreciation of the role of science in society.

- Martin stated a good thing about science was “we discover things to make our lives better” and for a ‘bad thing about science’ he stated, “we might discover something that could bring our downfall” (open response, survey);
- Alana said in response to ‘why we do science in school’, “I think it is fantastic because science helps people live and (science) creates new things like spaceships and people can go into space. It is practically all around you science, everywhere you go there is a mixture of science everywhere” (interview response); and
- Tyson responded to the same question with “well it basically gets us ready for the whole world that is coming towards us in the next few years. Well there is erosion, it basically helps us to understand things that are very difficult to understand” (interview response).

In year seven the following responses, from three high ability females, to the question of “why we do science in school” indicated that these students also saw the relevance of science:

- “we learn about stuff in the world, like everything has got to do with science” (Belinda) (individual interview response);
- “it is practically the main subject because everything is practically science and I guess you need to learn it” (Alana) (individual interview response); and
- science helps you “with just about everything” (Anne) (individual interview response).

The responses to “why we do science in school” could be categorised into three groups (some students included both groups in their responses):

- ‘life skills and knowledge’;
- ‘for your careers’; and
- ‘unsure’.
The ‘life skills and knowledge’ response was unchanged in year six (14 [of 21] and year seven (14 [of 20], 9 females and 5 males). However there was a marked increase as ‘careers’ being the perceived reason why students study science in school from year six (4 [of 21]) to year seven (14 [of 20], 7 females and 7 males). Bob and Jake were unsure why they studied science in school in year six and Jake was still unsure in year seven (2 of 20). Not clearly understanding the relevance of science or that science is necessary for all students may add to ambivalence to, or a decline in interest in, science.

School science relating to science in society

During focus groups in year six, Martin (7L) and Cara (7K) and Alec (7K) discussed how it would be good if science related more to life and “everyday things”. Martin gave an example how school science could relate to a life situation: “when learning about water students could go on excursions to waterways”. In the same focus group Alec discussed how carrying out a distillation task or setting up a water wheel would be a way of making a “boring” topic such as water more interesting and relevant (Appendix I). Four high ability male students in 6H discussed how they would like to go on more excursions in general as they were a desirable way of making science relevant to life, for example, visiting science museums or botanic gardens.

The responses discussed in this section (relevance of ‘science in society’ and of ‘school science’) imply that several of these students see the role of science in society but may not be experiencing science in their classes that reflects this appreciation. This may impact on their interest.

2b. Retaining and Losing Interest in Science

The following looks at factors influencing students’ interest in science:

i. the impact of specific classroom environments;
ii. parental influence
iii. social involvement or peer support
(i) The Impact of Specific Classroom Environments

There were a variety of teaching styles amongst the four, year six classes (in 2004) and the six, year seven classes (2005) that reflected the above distinctions drawn out from the students’ voices. There appeared to be a ‘class’ and/or ‘teaching’ effect relating to these characteristics that was consistent with the students’ voice and individual ‘Science interest’ scores.

Practical Science, Copying Notes and Theory, and Rushing Through Topics

The year six teaching emphases and classroom environments: observational and ‘Science interest’ score data –

The high ability class (6H). The students took part in extensive ‘copying’ of notes from the board; there was also considerable discussion, which was often teacher-centred but did include student discussion and debating of topics such as environmental issues in science. These students also spent a large amount of time in independent research, for example, researching topics on the computer and in books and some students participated in their own experiments at home. Students used computer power point presentations for science themes at school. However, they did very little practical science. Of the eight participant students in 6H, seven had high ‘Science interest’ scores in year six; the large percentage of students with high interest in science may have been influenced by their enjoyment of the independent research on the computer, taking part in discussion about science, participating in science experiments at home or a general interest in ‘science in society’.

The other three primary classes. In contrast the other three classes (6R, 6T and 6S) presented science as a student-centred practical experience, where students were encouraged to investigate and explore. Examples of activities included carrying out fair tests to identify rocks that they had collected (6S), taking part in sensory activities and carrying out fair tests on mystery liquids to identify them (6T); and students designed their own individual investigations such as setting up a range of foods in different conditions and locations to observe micro-organisms (6R). ‘Copying’ in these three classes was kept to a minimum. The classes, 6R and 6T, were managed by casual teachers for the first half of the year and science was rarely presented. In these two classes, science was only presented regularly in the final two terms when permanent teachers were assigned to the
classes. In these latter three classes eight (of 11) students had high ‘Science interest’ scores (for an overall picture of each class see the narratives of schools, classes and teaching styles, Appendix H).

The year seven teaching emphases and classroom environments: observational, ‘Science interest’ score data and students’ voice

In secondary school in 2005 the students were distributed amongst all year seven classes and a diversity of teaching styles were apparent. There was a noticeable difference between classes regarding the amount of practical science experienced and the amount of time spent ‘copying notes’. Most students experienced ‘teacher-centred’ science where the students participated in ‘recipe like’ practical lessons and were often told beforehand the results of the experiments. Independent research, for example, individually researching topics on the computer or in books, consisted of a small number of homework projects completed by all year seven students. From teacher interview data it appeared that the secondary teachers were generally positive regarding the participant students’ behaviour in the classroom and their attitudes towards science, with the exception of Clay and Jake in 7H (discussed below under class 7H) and Charlotte who generally was positive about science but was distracted in class (7P).

Classes 7L, 7P and 7S. There were a number of factors associated with these classes:

- relatively more practical activities,
- opportunities to explore with materials,
- less copying of notes
- and impact of classroom management.

These were classes where there appeared to be more practical lessons, less copying of notes and slightly more student-centred work, for example, students were given the opportunity to explore and investigate for themselves during experiments such as looking at objects through the microscope and with a hand lens (7L, 7P) and testing various objects for conductivity (7S), although overall these classes were teacher-directed. Ethen who was in 7L, said during an interview, “the experiments are fun and interactive and instead of doing writing we do gluing” (pasting printed notes into books). In these classes:
• One student (Daniel, 7S) increased in ‘Science interest’ by more than 8 points. Eight of the 10 students (80%) from these classes maintained a ‘high interest in science’ over the primary/secondary interface (Table 5.6). Two students (Harry, 7S and Tyson 7L) did not maintain ‘high ‘Science interest’ scores in year seven. Although five students had slightly lower ‘Science interest’ scores in year seven, only one (Harry) had a ‘Science interest’ score that decreased by eight points or more (see ‘after the primary/secondary interface: participants as individuals’ above). However when looking at Harry’s qualitative data, he stated that he preferred science in secondary school and appeared to show interest in, and motivation towards, the science activities during classroom observations. It appears that the majority of the students from these classes generally maintained a positive attitude to, and interest in, science. Tyson’s (7L) ‘Science interest’ scores marginally declined (51 to 48) but were in the ‘medium’ range in both year six and year seven. He did appear to be distracted during classroom observations and appeared to be least motivated with his science activities particularly later in year seven. According to his teacher, Tyson had decreased in interest in school generally and his teacher believed it was a result of factors outside the classroom.

• Martin from 7L is one of three students who was identified from narratives to have an outstanding interest in science in year six and all the qualitative data revealed he maintained his ‘spark’ for the subject and personal interest in science in year seven. This special interest in science is discussed further under ‘students with a passion for primary science’ below. It appeared that Ethen from 7L had developed a ‘personal interest’ in science in year seven and this is discussed further below (see section 3[ii]).

• Matt and Charlotte were in 7P, a large class where there were a number of students with behavioural problems and learning difficulties. Two teachers and a teacher’s aid often managed 7P. The class was given a large amount of practical science and ‘copying’ was kept to a minimum. Matt maintained a positive attitude and a ‘high interest’ score in science and stated that he enjoyed science more in secondary school but he did comment on how difficult it was to concentrate on his work in such a noisy environment. When asked what he would do if he could plan science during a focus group in year seven Matt responded, “I would do writing and experiments like my teacher does”. He appeared to be very satisfied with the
amount of practical science presented in year seven and during researcher classroom observations, Matt was motivated during science activities, appeared to be engaged with the learning and maintained a high interest in the subject. However his teacher commented that although some days Matt was interested and focussed on science other days he would appear to be distracted in his science lessons. His teacher also commented on the difficulty for students to remain focussed in a class with so many students who had behavioural problems and were ‘off task’ during lessons and this was not confined to science, with this particular class group.

Charlotte said she enjoyed the practical aspects of science, although she appeared to be distracted during class and showed little interest in the subject. During researcher observations she did not appear to be motivated towards her activities or engaged with her learning in year seven and this was confirmed by her teacher’s comments. She appeared to be more motivated towards science practical activities in year six although she did lose interest quite quickly, particularly if she found the task difficult. During a focus group Charlotte stated that she preferred science in primary school. Charlotte’s quantitative ‘Science interest’ score showed a marked increase in ‘Science interest’ in year seven. As Charlotte may have had difficulty reading the questions in year six due to her learning difficulties and possibly relied on a friend to give her the answers, the result may not have accurately reflected Charlotte’s true ‘Science interest’ score in year six as Charlotte’s quantitative survey was almost identical to Mayan’s year six score. Therefore Charlotte’s increase in ‘science interest’ over the primary/secondary interface was disregarded.

Class 7K. There were a number of factors associated with 7K. These included:

- decreasing practical activities and excessive writing;
- high expectations and teacher/student dialogue;
- rushing through content;
- some students losing passion for science; and
- students’ interest decreasing and students maintaining interest as they moved from primary into secondary in science.

Decreasing practical activities and excessive writing appeared to be associated with 7K. The seven students in 7K, three (Alec, Tatiana, and Belinda) were amongst those five
students whose ‘Science interest’ scores decreased considerably over the primary/secondary interface. Anne who had a very high score (70) in year six did show a decrease in ‘Science interest’ by seven points (63) although frustrated with aspects of her year seven science she did appear to maintain her interest in the subject and her score was still in the high range. This class was a high ability class where there was an extensive amount of ‘copying’: this was evident from observing science work books and from classroom observations. All seven students in 7K complained about the large amounts of ‘copying’ both from the board and from textbooks and all stated that they would like to do more practical activities in science. In her interview Alana said, “I like doing experiments except we hardly ever do them any more. We used to do a lot (earlier in the year) but now we just write”. During a focus group Cara from 7K said, “I don’t like theory, like writing in our books, it sucks, cause if you stop for a second then you have heaps and heaps of stuff to do, cause they just keep writing... it is really annoying and I don’t like writing”. In contrast, Bree (originally from 6R and then in 7R) said “I thought secondary school would be lots of writing down and I didn’t think there would be so much prac in secondary school. Secondary School is better than I expected”. Anne and Alana would prefer clearer explanations in science lessons in preference to the use of complicated scientific language. During a focus group Anne commented on her frustration when she asked for explanations of difficult concepts and was told find the answers.

The teacher of 7K had high expectations of the students regarding their scientific diagrams. All participant students received negative comments in their books from their teacher regarding their drawings, including those with neat, precise, scientific drawings. Tatiana and Anne stated in interviews their frustration with this expectation. Anne commented on her dislike of the expectation of being precise with her report writing (See Appendix H, Narrative of 7K and individual narratives of these students Appendix I). Even though the teacher generally was quite positive in her comments during the teacher interview regarding the participant students’ behaviour in, and attitudes towards, science lessons, during classroom observations of teacher/student dialogue the teacher used slightly sarcastic comments. Although this was intended as humour, some students appeared to feel devalued as a result of these ‘smart’ comments, possibly having an impact on their self-esteem in science. However, no specific dialogue of this nature was transcribed.
There was a large amount of content presented in 7K and the students often felt they were being 'rushed'. This was evident from students’ comments and observations of lessons and workbooks. Alana and Anne from 7K raised concerns relating to the lack of time allowed for the completion of tasks. They believed the teacher rushed through the topics.

Two students in 7K appeared to lose their ‘passion’ for science. These two students, Alec and Alana, appeared from the qualitative data to lose their ‘spark’ for the subject. They were two of three students who emerged from their narratives as having an exceptional interest in science in year six; Alec also had a very high ‘Science interest’ score in year six (a score of 73 from a possible 75). This matter is discussed further under ‘passion for primary science’ below.

Out of the five students who had a decrease in their ‘Science interest’ scores by eight points or more, three were from 7K (Alec, Belinda and Tatiana). Alec remained in the high interest range but his science score decreased markedly (by 12 points) (Table 5.6) as he had an exceptionally high interest science in science (as mentioned above). Belinda’s score decreased to the medium interest range over the primary/secondary interface (with a score reduced by 9) and Tatiana’s score, remained in the medium interest range but decreased by more than nine points (Table 5.6). It was not possible to compare the students’ ‘Science interest’ scores in 7K with the scores of other students in year seven, as the sample sizes were too small to be effective in a statistical test. It does appear from both qualitative and quantitative data, that the majority students in this high ability class experienced a decline in positive attitude towards science. Bobs ‘Science interest’ score increased slightly over the primary/secondary divide and he did appear to become more interested in science in year seven. However the other six students in 7K ‘Science interest’ scores decreased (Table 5.6).

Class 7H. The factors associated with this class included:

- limited practical activities due to a lack of time; and
- a large amount of copying notes.
Clay and Jake who were in 7H in year seven were in the mixed ability class 6T in year six. The teacher of 7H spent the majority of the lessons talking or writing notes on the board and Clay and Jake displayed disruptive behaviour during such times along with a number of other students. Each time this class was observed the practical activity was not started until the last 10 minutes of the lesson. The students would rarely complete their tasks, as time was so limited. Clay and Jake mentioned their disappointment and frustration in the lack of time for practical activities and the large amount of ‘copying’ and general theory which they described as “boring”. The teacher stated quite unquestionably that he believed these students’ attitudes towards science were poor and that they were not interested in the subject. It was noted that:

- Jake’s attitude to science (and possibly to school generally) was not very positive; this was confirmed by student interviews and classroom observations in addition to teacher interviews, both in year six and year seven. Jake did appear to become a little more positive towards science in year seven, but this was mainly towards the practical lessons. His ‘Science interest’ score remained in the medium range over the primary/secondary interface.

- Clay maintained his very high ‘Science interest’ score in year seven, even though he strongly disliked copying and would have preferred to be doing more practical lessons. He was very keen to answer questions in science classes and sometimes called out the answer if he was not chosen to answer the question. Clay’s secondary teacher during an interview described his apparent enthusiasm and desire to discuss aspects of science as “attention seeking, disruptive behaviour” and he did not believe Clay had a genuine interest in the subject. Despite his teacher’s comments, from all other data Clay appeared to have interest in science, motivation towards the practical activities, was ranked third in the class with his assessment, and was keen to let the researcher know how interested in science he was. Science was amongst his favourite subjects in both year six and year seven (although he specified the practical activities in science in year seven, not the theory). Clay certainly appeared to enjoy being given ‘a voice in science’ and having his ideas taken seriously (see the narratives for schools, classes and teaching styles, Appendix H, for a general picture of classroom environments).
Chapter Five

Teaching Emphases and Classroom Environments: A summary

There appears to be a consistency between the students’ voice, their maintenance or decline in ‘Science interest’ scores and the teachers’ different emphases on the use of practical science activities (i.e., whether included and if there was sufficient time allowed) and the copying of notes in year seven. Clay was a possible exception although his class did still include some practical activities, even if they were presented in a limited time; further there was the influence of other variables such as classroom management.

Interestingly in year six, the class where the most writing occurred still had a very high proportion of students with high ‘Science interest’ scores; the independent research on the computers, the students’ use of power point presentations with science themes, the screening of science videos and classroom discussion of science topics, provided other opportunities that may have retained student interest.

(ii) Parental Influence

The results of the survey issued in 2004 to parents of the year six participant students (N=15; 75% response rate one or both parents) indicated that most parents said that they liked science with seven stating that they particularly liked the practical aspects of science. Bob and Alana, who maintained their high interest in science over the primary/secondary interface, both had one parent who did not especially enjoy science while the other parent, did enjoy the subject.

Of the 5 students whose ‘Science interest’ scores decreased markedly over the primary/secondary interface, Bree, Belinda and Alec had both parents stating that they enjoyed science and Tatiana had one parent who completed the survey and said they liked aspects of science. Harry’s parents did not complete the survey. Daniel, whose ‘Science interest’ score increased over the primary/secondary interface, had one parent who said that he or she liked science. It was not possible to discern any pattern for these students’ interest in science and their parents’ views.
(iii) Social Involvement or Peer Support

In this case study the impact of peers or social involvement may have been a variable relating to the decline in student interest in, and positive attitudes to, science. This variable also could have been related to students maintaining their positive attitudes towards science. When analysing the data of one of the three students who displayed a passion for science in year six, ‘spending time with friends’ (or social involvement) amongst other interests appeared to replace Alana’s ‘personal interest’ in science. Alana revealed her love of agriculture and working on the land with her father in year six, at this time she also related her agricultural interests to her school science and stated that she loved everything about science (see ‘Students with a Passion for Primary Science and the Transition’ below, and Appendix H).

Charlotte appeared distracted by her peers, who were not study participants during her practical science classes. From her observational and focus group data, her interest in science appeared to decrease over the primary/secondary interface and she remarked on how she preferred science in primary school (see above ‘Impact of Specific Classroom Environments’, and Appendix H).

Bree was the only student who was in a class without any other study participants in both year six and year seven, and she was one of the five students whose interest decreased markedly over the primary/secondary interface (see below under ‘Students whose science interest score decreased markedly’ and Appendix H). Lack of peer support may have been associated with this decline in interest. All other students in the case study were in classes where at least one or more of their peers were also study participants. Most of these students maintained their interest in science over the primary/secondary interface apart from the following four students:

- Alec, Bree and Tatiana’s marks decreased in interest over the primary/secondary interface but this decrease appeared to be largely associated with classroom environment (see above under ‘the impact of specific classroom environments’ and Appendix H);
• Even though the qualitative data suggested Harry was motivated and engaged towards practical science in secondary school and achieved high marks in his science exams, his ‘Science interest’ score markedly decreased. He displayed social problems in both primary and secondary school, and in year seven appeared to prefer to work individually during practical science tasks. During observations there was evidence of teasing from other students and his teacher highlighted his social problems and how some students displayed negative behaviour such as bullying tactics, towards Harry (see below under ‘Students whose science interest score decreased markedly’ and Appendix H). It is evident that social factors may have impacted on Harry’s decline in ‘Science interest’.

3. Focus on Specific Students and Groups of Students

In order to discern further reasons for students changing or maintaining their levels of interest across the primary/secondary interface, participant students were divided into groups on the basis of various qualitative observations of their ‘Science interest’, these groups were:

i. Students with a Passion for Primary Science across the Primary/Secondary Interface;

ii. Students who had a High ‘Science Interest’ Score (>58) in Year Seven and Either Slightly Increased their ‘Science interest’ Score or it Remained Stable (did not change by >7) Over the Primary/Secondary Interface;

iii. A Student whose Change in ‘Science interest’ Score was not able to be calculated over the primary/secondary interface but her qualitative data revealed an increase in science interest as she moved from year six into year seven;

iv. students whose ‘Science interest’ scores decreased markedly over the primary/secondary interface; and

v. students whose ‘Science interest’ scores increased.

This section is concluded with a summary related to these specific student groups (see vi).
(i) Students with a Passion for Primary Science across the Primary/Secondary Interface

The qualitative data indicated that three high ability students, Alec (6H, ‘Science interest’ score 73 (out of 75), Martin (6H, 67) and Alana (6S, 63), ‘stood out’ from amongst the participant students in year six as being extremely passionate about both school science and science in society and had a personal interest in science. Alec and Martin were highly enthusiastic about the experiments they were conducting at home which they carefully documented in their journals when in year six. During classroom observations they were keen to take part in class discussion and appeared to be ‘engaged with content’ (Pugh, 2004) and all seemed to be ‘intrinsically motivated’ towards science activities. They both related their content to experiences outside the classroom and were keen to carry out experiments to solve their own problems such as investigating substances to create their own ink. Their year six teacher remarked on their exceptional interest for the subject. Alana who was from a different school to Alec and Martin in 2004 also appeared passionate about the subject in year six and said that she loved everything about science. In one of her interviews Alana said “people have done science for so many years and it’s just interesting that school kids can learn about it too”. While in year six Alana enjoyed spending large amounts of time helping her father on their farm and related her school science to her experience on the farm such as learning about the formation of soil. Her strong love of science suggested she had a ‘personal interest’ in science that extended beyond her school science lessons (Hidi, 1990).

In Year seven, these three students’ ‘Science interest’ scores remained in the high category, but it was apparent that changes in interest had occurred in two instances. It was noted that:

- Although there was a slight decrease in Martin’s ‘Science interest’ score after moving into secondary school (from 67 to 63, in 7L) it was apparent from all the other data that he had maintained a keen interest and enthusiasm towards the subject, was motivated towards his activities and appeared to be ‘engaged with content’ (Pugh, 2004).
- In contrast Alec’s qualitative data confirmed deterioration in interest towards school science in year seven (he was in 7K) and he recorded the largest decrease in
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'Science interest’ scores (by 12 points to 61). Alec’s sub-scores of ‘Science interest’ all decreased by 3-5 points (‘Independent investigator’, 27 to 22, ‘Science enthusiasm’, 22 to 19, ‘Social context’, 24 to 20), his ‘Difficult science’ score increased by one point (Table 5.6) (See Chapter 4 for information about the various sub-scales). Alec’s teacher during an interview said she thought Alec had lost “a bit of interest and zest for science”. Although interested and motivated during practical activities Alec appeared to be unmotivated during discussions and distracted by other students in his science classes.

• Alana’s (7K) ‘Science interest’ score remained relatively stable over the primary/secondary interface (63 to 59), but her qualitative data indicated a decline in ‘Science interest’. Science was no longer one of her favourite subjects in secondary school; she stated that she preferred science in primary school, and she appeared more interested in subjects such as English, PE and wood technology (Table 5.7).

Alana thought that science was more difficult in year seven while Martin and Alec’s ‘Difficult science’ scores did not vary, both agreeing that science is neither easy nor difficult. An analysis of these students’ ‘Science interest’ sub scores indicated that Alana’s changed very little, Martin’s ‘Independent investigator’ score reduced by about 20% (5 points), while Alec had reductions on all three sub-scales of 10% or more. From what was discussed earlier in Chapter five, the attributes that characterised class 7K may have impacted on Alana and Alec. However, Alana spent less time helping her father with the farm in year seven as she had more homework commitments. Alana also mentioned during her interview that she enjoyed spending time with her friends and going to drama school. It is possible that Alana’s interests had changed as a result of her social life in secondary school and interest in drama, which had taken the place of her enjoyment of working on the farm, which was a science-based interest and she no longer appeared to have her strong ‘personal interest’ in science. Her classroom environment in secondary school may have influenced Alana’s outlook to science, as she stated that she preferred science in primary school. Although Alec’s ‘Science interest’ score declined markedly in year seven and he was particularly frustrated with the large amount of writing and lack of independent research in secondary school, science remained one of his favourite subjects at school, and he continued to take part in science experiments at home and has retained his interest in
following a career in veterinary science; he also maintained his ‘personal interest’ in science in society but appeared disappointed with science in secondary school. Martin preferred science in secondary school and continued to maintain his ‘personal interest’ in the subject, even though he said he did expect more independent research (like he participated in while in primary school [6H]) and more experiments in secondary school science. Martin stated his enjoyment of topics involving animals and plants, especially when they were topics in year seven science: participating in these topics could have helped him maintain his interest in science.

(ii) Students who had High ‘Science interest’ Score (>58) in Year Seven and Either Slightly Increased their ‘Science interest’ Score or it Remained Stable (did not change by >8) over the Primary/Secondary Interface

Eight students fell into this category, five boys (3 of high ability, 2 of mixed ability) and three girls (2 of high ability, 1 of mixed ability).

- Bob’s score marginally increased from medium (55) to high interest (59) over the primary/secondary interface. Although motivated towards and interested in science in primary school, he appeared to be more motivated towards science in secondary school and his teacher believed he had a keen interest in the subject. According to Bob science was interesting in primary school but he believed parts of science were more interesting in secondary school. However Bob disliked the large amounts of writing in science. The qualitative data did appear to support the quantitative science scores where Bob maintained his positive attitude towards the subject but there was a slight increase in his science interest score as he went from primary into secondary school.

- Roxy, Clay, Matt, Cara, Martin, Alana and Ethen all maintained their high ‘Science interest’ scores in year seven and their scores remained relatively stable across the primary/secondary interface (did not decrease by more than four points). With the exception of Alana and possibly Cara, the qualitative data relating to these students revealed they maintained their positive attitude to, and interest in, science over the primary/secondary interface. This was evident in the observational data where these students displayed motivation towards science activities and appeared to be interested in the subject. The students’ interest in science was also revealed in interviews, focus groups and surveys. Alana’s ‘Science interest’ score remained
stable but her qualitative data appeared to show a decline in positive attitude towards the subject (as mentioned under 'passion for science'). Cara did not stand out as having a 'personal interest' in science in year seven, but she did appear to have retained her interest in science as she moved from primary school into secondary school. She was motivated towards the practical science activities but was sometimes distracted during theory lessons in both year six and year seven. However Cara commented on her intense dislike of the large amount of theory, particularly the copying of notes in 7K (as discussed under 'Year 7 teacher emphasis and classroom environments'). Cara was very engaged with her individual science research projects in year six and was always keen to show the researcher her science work-book; she did not appear to be quite as keen about science in year seven and her 'Science investigator' score decreased by three points over the primary/secondary divide. However her desire to pursue a career as a medical research scientist to find a cure for cancer was apparent in both years six and seven.

- Ethen, like Martin appeared to be 'engaged with content' in science. His teacher said how Ethen loved to discuss his experiences outside the classroom relating to science. Ethen sometimes remained in the science classroom during the lunch or recess breaks to discuss aspects of science and asked for clarification of his ideas relating to science topics. It appeared that Ethen might have developed a 'personal interest' in science in year seven.

- Of these students who maintained their interest in science, five listed science amongst their favourite subjects (Clay, Matt, Ethen, Martin and Tia) and four stated that they preferred science in secondary school to primary school (Clay, Matt, Bob and Martin) (Table 5.6).

**Other Characteristics of These Students who Retained 'High Science interest' Scores**

- Clay (68 to 66), Matt (68 to 67), Bob (55 to 59) and Martin (67 to 63) particularly liked aspects of science involving the use of equipment such as Bunsen burners or things that explode in secondary school science, while Roxy (67 to 67) liked using chemicals and looking at cells through the microscope in secondary science. Clay, Matt, Bob, Martin, Ethen (61 to 60), and Roxy, all said how they liked the fact that there were more experiments in secondary school compared to primary science, but
Martin said he expected even more experiments in secondary school and Roxy said she would have preferred more time in science in order to continue on with her experiments like she did in primary school.

- Cara (68 to 65) liked experiments and watching videos in secondary school but as previously mentioned she particularly disliked the excessive amount of writing in her class or working out of the text in year seven (7K). Ethen and Martin would have preferred more individual research on the computer in secondary school.
- Cara and Alana (from 7K) thought science was more difficult in year seven: their ‘Difficult science’ (DS) sub-scores increased markedly (by 5 points to 11 and 12 [out of 15] respectively). The others’ scores remained the same or changed marginally (by 2 points or less) but Matt (13 [out of 15]) and Bob’s (12 [out of 15]) scores did indicate that they did perceived science as difficult, rather than easy (Table 5.6).

In summary, most of these students appeared to retain their interest in science because of:

1. the practical nature of their science activities (6 [of 8]); and
2. their exciting content or unusual equipment (5 [of 8]).

At least two of these students indicated they would have preferred even more practical tasks or more time on those that they encountered and taking part in activities such as watching videos. Although these students retained their high ‘Science interest’ scores at least one had a strong dislike of writing in science and two would have preferred more time to independently research science topics. Half of these students (4 [of 8]) perceived year seven science to be difficult rather than easy, with two believing it to be much more so than in primary school (Table 5.6).

(iii) A student whose change in ‘Science interest’ score was not able to be calculated over the primary/secondary interface but her qualitative data revealed an increase in science interest as she moved from year six into year seven.

The ‘Science interest’ scores over the primary/secondary interface for Tia, were not able to be compared, as her attitudinal survey was incomplete in year six. She appeared highly motivated and engaged during observations in year seven science classes and this was
reinforced by comments from her teacher who stated how she concentrated and was focussed during science resulting in excellent science exam results where she was ranked fourth in the class. Science was amongst Tia’s favourite subjects in year seven and she was able to see the relevance of learning science at school. She appreciated the large amount of practical science in her classroom and the use of interesting science equipment such as microscopes and Bunsen burners. She continued to want to pursue her goal that was evident in year six, to study veterinary science. Her ‘Science interest’ score was at the high end of the medium range (58) in year seven and it was possible that she may have developed a ‘personal interest’ in science over the primary/secondary interface. In addition to Ethen and Martin who maintained their high interest in science in year seven, Tia was in 7L, a classroom where there was a large amount of practical science, and where copying of notes from the blackboard was kept to a minimum.

(iv) Students whose ‘Science interest’ Scores Decreased Markedly Over the Primary/Secondary Interface

Five students’ ‘Science interest’ scores decreased by more than 8 points over the primary/secondary interface, with three of these still retaining high scores while the others (2) were in the medium range. Three were girls (two high ability) and two were boys (one high ability). As indicated above the qualitative data, in general, was consistent with these ‘Science interest’ scores:

- Alec and Belinda’s scores, although decreasing considerably, remained high in secondary school. Alec’s primary ‘Science interest’ score was the highest score recorded (73 [out of 75]) from the 264 students taking part in the attitudinal survey in 2004 (Chapter 4). Both these students listed science among their favourite subjects.
- Harry and Bree’s scores decreased from high (year six) to medium (year seven); and
- Tatiana’s score remained in the medium range over the primary/secondary interface.

Characteristics of These Students whose ‘Science interest’ Scores Markedly Reduced

In summary, all five of these students particularly disliked writing in science and all had an increase in their ‘Difficult science’ sub-scores over the primary/secondary interface,
from marginal (up 1 in 15 points) to extensive (up 10 in 15 points, Table 5.6). Three of these students (Alec, Belinda and Taitana) would have preferred more practical work while Bree, who was in a year seven class with relatively more practical activities, did not like how the teacher directed experiments and told students what was going to happen before carrying out experiments: this was in contrast to her year six experiences where she designed her own experiments and carried out fair tests. Three (Alec, Belinda and Tatiana) were in 7K and the other two were in 7R (Bree) and 7S (Harry). In 7K writing or copying of notes was a very common practice and the practical science was teacher directed with little initiation by the students (see ‘the impact of specific classrooms’).

Other more specific details that characterise these students are:

- Belinda and Tatiana enjoyed the practical lessons in secondary school and said that they would prefer to be doing more practical activities and less writing in secondary school. They both particularly disliked summarising from the text in science. Tatiana said she would like her year seven science teacher to “explain things better”. She preferred science in primary school and although Belinda achieved high marks in her science exam in year seven, her science difficulty score had substantially increased from year six to year seven by five points. Belinda’s qualitative data indicated she had maintained her interest in science but she did voice aspects of year seven science that she found frustrating (mainly relating to teacher and classroom environment) and this may have influenced her science interest score. Tatiana’s qualitative data supported her decrease in interest in year seven to an extent. She displayed interest in science in year six but she was not a student who stood out as having a ‘personal interest’ in science. Tatiana found aspects of science difficult in year seven, and disliked the large amount of writing of science notes. However she did reveal motivation towards, and engagement, with the science practical activities, and although the teacher stated that Tatiana struggled with conceptual understanding, observational data revealed an understanding of conceptual ideas during theory lessons. She stated that she preferred science in primary school, as she believed it was more fun when she was able to carry out student-centred investigations, which involved the students devising fair tests.
• Bree’s qualitative data revealed that she was motivated towards science in general; she enjoyed practical science in secondary school with the use of more sophisticated equipment but she did not perceive secondary science as either easy or hard. As stated above (under ‘teacher and classroom environments’) Bree was highly motivated and engaged with her independent investigations in primary school and stated how she would prefer to be doing more student-centred investigations in secondary school and this may have influenced her science interest score.

• The qualitative data revealed that Harry displayed motivation and engagement toward practical activities in year seven. However both in year six and year seven he had trouble relating to, and working with, other students. In year six he appeared to be unhappy to work individually in science but in year seven he was engaged and focussed and worked efficiently on his own although he became frustrated when other students attempted to tamper with his equipment. Both his primary and secondary teachers said that Harry had difficulty relating to the other students. His secondary teacher said that Harry was happy to work individually, he was focussed and engaged with his science work and that he had achieved very high marks in his science exam. Harry’s social problems may have impacted on his self-confidence and perhaps he was extrinsically motivated towards his science activities in order to achieve high marks in science, rather than having a desire to learn related to a ‘personal interest’ in the subject. Harry disliked writing in science and he stated that science was fun in secondary school, when there was no writing, particularly the practical lessons; he did not perceive secondary science as either easy or hard. Harry’s qualitative data suggested that he had maintained his interest in science, but it was difficult to determine if he had maintained his positive attitude towards the subject. Copying of notes was more frequent for Harry in year seven science, compared to his year six science lessons, but there appeared to be less copying of notes in his class (7S) than some other year seven classes. Harry’s strong dislike of writing and his social problems may have influenced his quantitative ‘Science interest’ score.

• Alec was an unusual case, because, as mentioned earlier, he appeared to lose his exceptional, passion for science over the primary/secondary interface, but science still remained one of his favourite subjects. His perception of the difficulty of
science was unchanged. Alec loved experimenting at home and enjoyed using equipment such as Bunsen burners and he said he would like more practical science lessons, less writing and more independent research using the computers in secondary school. Perhaps his reduction in exceptional interest in science was more related to what he was doing in class.

In summary these students’ decreased interest in science related to:
1. dislike of writing;
2. failure of secondary science to meet their expectations related to the amount of practical work involved;
3. increase in perceived difficulty of the subject (with some students); and
4. lack of opportunities for decision-making and independent research.

(v) Students whose ‘Science interest’ Scores Increased

- Three students Daniel, Jake and Bob (excluding Charlotte), had an increase in their ‘Science interest’ scores but Daniel was the only student whose score increased markedly (>8 points); his sub scores on the “Science enthusiasm’ and ‘Independent investigator’ sub-scales both increased by more than ten percent (Table 5.6).

Although appearing interested in science in year six, data gained from interviews, focus groups and observations supported Daniel’s increase in ‘Science interest’ over the primary/secondary interface. Daniel had a change in subject preference in year seven as science was not one of Daniel’s favourite subjects in year six, but in year seven it was. Daniel stated that he enjoyed science more in secondary school than primary school. Daniel particularly liked the practical aspects of science such as lessons involving Bunsen burners and microscopes. Daniel was the only student who said that he sometimes enjoyed writing in science and one of the reasons he gave was because he usually finished before other students allowing him time to sit and relax while the other students were continuing to write. However, in interviews and surveys, Daniel said large amounts of writing, was something he disliked about science. Daniel’s ‘Difficult science’ sub-score indicated that he perceived science as neither hard nor easy and his score remained stable over the primary/secondary interface. Daniel was a little confused between science and geography (in the
Human Society and its Environment [HSIE] NSW Key Learning Area) in primary school and stated that learning about different countries was part of science: whether this influenced his interest score in year six is problematic. His year seven teacher felt he had a keen interest in the subject by the style of questions he asked during science lessons and how he liked clarification of his ideas. Daniel appeared to be developing a personal interest in the subject in secondary school.

(vi) Specific Students: A Summary

Although there was a consistency between the qualitative impressions of ‘Science interest’ across the primary/secondary interface and most of the obtained ‘Science interest’ scores (see Fig 5.1) this was not the case with all students. Even so a consideration of the above four groupings of specific students again suggests common factors have surfaced for why students in years six and seven like or dislike science. These factors have been mentioned previously and this alternative analysis adds further support to the earlier interpretations (to gain a complete picture of each students’ individual attitudes and interests relating to science, in both primary school and secondary school, see ‘narratives for student participants’, Appendix I).

4. Summary of the Results of the Case Study

Overall the student participants in the case study, as a group, generally remained positive towards, and maintained their interest in, science, as they moved from year six primary, into year seven, secondary. The majority of these students displayed motivation towards, and engagement in the practical activities, with some students maintaining or developing a ‘personal interest’ in science. This does not support the findings from the attitudinal survey that was administered in 2004 and again with the non-participant year seven students in 2005, which revealed a decline in positive attitude over the primary/secondary interface (Chapter 4). The secondary teachers endeavoured to present practical activities when their classes were observed as part of this study, so most observations took place during practical lessons. However when theory lessons were observed where students were asked to copy notes from the board, some participant students appeared distracted and disinterested. When looking closely at the results of the case study there appeared to be a considerable decline in interest amongst at least five (of
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20) of the participant students. Classroom environments, teacher influence and social involvement, appeared to be factors leading to a decrease in 'Science interest'. The classroom environments that students appeared to 'like' were those where they spent more time in student-centred, relevant practical science, where the students were in charge of their own learning and were given the opportunity to explore or investigate, discuss aspects of science and independently researched on the Internet. These were classes that were likely to encourage student motivation, and engagement. The classroom environments that students appeared to 'dislike' were those where there were copious amounts of copying of notes, science topics were rushed, student-centred practical science (practical science that encouraged independent investigation and exploration) was rarely or never facilitated, or where students felt humiliated by the teacher for an aspect relating to science (i.e., the students’ opinions, behaviour in science, or attempt to perform in a science task/activity). The use of ICT in science, going into the school grounds for science lessons, or science related excursions, were aspects of science that students enjoyed and these activities encouraged student interest. Gender and ability did not appear to be a major factor when determining the attitudes of these students towards science although slight differences were noted (namely more males said they preferred science in secondary school and only females preferred science in primary school); nor did there appear to be any connection between parents’ attitude to science and those of their children, although this cannot be ruled out.

Overview of the Following Two Chapters

Chapter 6 discusses the findings and implications for educators of the attitudinal survey and Chapter 7 discusses the findings and implications of the case study and how the two studies interrelate.
Chapter Six

CHAPTER SIX

ATTITUDINAL SURVEY: DISCUSSION OF RESULTS AND SOME IMPLICATIONS FOR PEDAGOGY AND THE CURRICULUM

Overview:

This is an interpretation of the findings of the quantitative attitudinal survey (which included two open-ended items), conducted in 2004 with 264 students from years five to ten. The findings have been discussed under the following headings:

1. declining attitudes across the primary/secondary interface: practical versus note-taking;
2. attitude decline in the secondary years;
3. factors impacting on students’ attitudes to science;
4. are these results science specific?;
5. responses to research questions and assertions regarding this attitudinal survey; and
6. implications from this attitudinal survey.

The findings from the qualitative case study are discussed in the following chapter (Chapter 7).

1. Declining Attitudes Across the Primary/Secondary Interface: Practical Science Versus Note-Taking

A number of Australian studies have reported the deterioration of students’ positive attitudes towards science over the primary/secondary interface from primary into secondary school. Speering and Rennie (1996) found that their sample of West Australian students were more positive about science at the end of primary school than they were in early secondary school. A large scale study (N= 1040 across 47 primary schools) by Ferguson and Fraser (1998) found that many students characterised their secondary classes as “taking notes” and “learning rules” and indicated that their science classes were not enjoyable or “proper science” (p. 395). In an earlier Victorian report, Baird, Gunstone, Penna, Fensham and White (1990) documented similar comments from a questionnaire with students in year seven whereas the vast majority of these students (93%) had written
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in year six that they “enjoyed science and were looking forward to doing it in year seven” (p.12).

Both the quantitative data and the short answer responses in this survey questionnaire support the deterioration in positive attitudes towards science over the primary/secondary interface. Specific secondary student comments that show this trend include “science used to be my favourite subject until starting high school”, “(there is) too much writing, not enough experiments” and “I hate everything about science”; in fact 47% of these students stated that “writing or theory” was a “bad thing about science”. Further, secondary (S) students were significantly less positive (2.72 on a 5 point scale) about writing in their science books than primary (P) students (3.42) and significantly more thought they were required to write too much (P: 2.00; S 2.30 on a 3 point scale) (see Tables 4.3 and 4.14). It seems that students would prefer to do practical science, with more than half of all students (57.5%) responding that practical activities such as experiments are a ‘good thing about science’ and this was supported by the very positive response to the doing ‘Science experiments’ item in the ‘Being in school’ sub-scale (P: 4.49; S 4.16) and the relatively more positive responses to some items in the ‘Independent investigator’ subscale. In a large scale (DETYA) study investigating teaching and learning in science in Australian schools “61% of secondary students indicated that they copy notes nearly every lesson, 59% of students indicated that the teacher never allows the students to choose their own topics to investigate and 33% are never allowed to plan and do their own experiments” (Goodrum, Hackling & Rennie, 2001, p. 155). However, Goodrum et al. (2001) reported that where science is presented in primary schools in Australia, it is often very practical and student-centred providing opportunities for the students to independently investigate, resulting in “high levels of student satisfaction” (p.154). In contrast Galton, Hargreaves, Comber, Wall and Pell (1999) stated that the introduction of the National Curriculum in the United Kingdom resulted in an increase in the more traditional type of teacher-centred science lessons in primary school in the period from 1976-1996. This traditional type of lesson involved a “one-way communication system” in the classroom, similar to the teaching in secondary school where teachers do the talking and the students listen (p. 33). This may be one of the factors influencing primary students’ attitude to science in the UK, where the trend of becoming less positive towards science is starting in late primary school (Pell & Jarvis, 2001). Ebenezer and Zoller (1993, p. 183) in their British Colombian study
(N= 1564) suggested that student directed practical activities were one of the aspects that influenced students to become more positive about science whereas extensive note taking, amongst other theoretical aspects, may have the reverse effect. There appears to be mounting evidence that there is a decline in interest in science across the primary/secondary interface and many students relate this loss of interest to an overemphasis on writing in secondary school science and not enough time devoted to students investigating.

2. Attitude Decline in the Secondary Years

Many studies have found this deterioration in positive attitude towards science continues as students progress through junior secondary school (Baird, et al, 1990; Simpson & Oliver, 1985, 1990; Yager & Yager, 1985). Although there was a significant drop in ‘Science interest’ from primary into secondary school in this study, the ‘Science interest’ scores did not significantly differ from year seven to year ten. What was noticeable was that higher ability secondary students scored higher than lesser ability peers on several scales and more towards year ten and secondary males scored higher on a few scales than females, and again more towards year ten.

3. Factors Impacting on Student Attitudes to Science

This factors impacting on student attitudes to science are discussed under the following headings:

a. gender differences towards science in primary and secondary years;

b. science as a difficult subject;

c. the teacher and science attitudes;

d. student-centred investigations;

e. negative images of science’s role in society;

f. relevance of science;

g. science as dull; and

h. science for the intellectually elite
Chapter Six

a. Gender Differences Towards Science in Primary and Secondary Years

Some studies have revealed gender differences in the attitudes of students’ towards science. Jones, Howe and Rua (2000, p. 189) found there were significant gender differences in primary students (N=437, grade 6) “attitudes towards science, perceptions of science courses and careers”. The TIMSS report (age 14 data), in countries where science is taught as a single subject, discovered that there was a significant gender difference on average showing boys’ attitudes towards science were more positive than girls. In countries where science is taught as separate subjects on average more boys were positive towards physics, chemistry and earth sciences with more girls being positive towards biology (Martin et al., 2000). In a British study (N=93; ages 11 to 13), Colley, Comber and Hargreaves (1994, p. 14) noted that boys rated science significantly higher than girls in their subject preferences, while Hendley, Parkinson, Stables and Tanner (1995, p. 94) found that boys held a more positive attitude to “enjoyment in science” (and technology and mathematics) than girls (N=4,263, Wales ages 13 to 14).

In an Australian study by Ferguson and Fraser (1998, p. 395) the students were asked to rate their subjects, before and after movement across the primary/secondary interface; the results indicated that science was more popular with boys than girls. Similarly in Baird et al. (1990, p. 13) the responses to a questionnaire revealed that 50% of girls believed science was “worse in year seven” compared to 33% of boys responding this way. The trend of girls losing interest more so than boys has not been universal and the gap may be narrowing (Osborne, 2003). Murphy and Beggs (2003, p. 115) found the reverse in their study of students aged 8 to 11 in Ireland, where girls were more positive than boys in their enjoyment of science. In a study by Simpson and Oliver (1990, p. 7) in the USA, males portrayed a “more positive attitudes to science whereas girls appeared more motivated to achieve in science”. However Simpson and Oliver concluded that boys and girls “felt and behaved towards science in much the same way”.

In this study there were generally no significant differences in gender sub-scale scores in primary or secondary apart from years 5 and 9, where primary boys were significantly more positive within the categories ‘Independent investigator’, ‘Social context’ and
Chapter Six

'Science interest', while secondary boys were more positive towards the 'Independent investigator', 'Science enthusiasm', and 'Science interest' scales (See Chapter 4 for explanation of these sub-scales). It is difficult to be definitive, but the general trend in the data in this study does still suggest that there could be a gender effect that impacts on interest in science that must be considered: as Murphy (2001, p.22) stated "gendered learning is a phenomenon that is not going to go away".

b. Science as a Difficult Subject

Hasan (1985), in a study of 313 students (aged 16 to 19), found that there was a relationship between attitude towards science and the students’ perception of their abilities in science. In this study higher ability secondary students scored higher in their interest towards science than their lower ability peers (Table 4.11). They also tended to score more highly on all scales than other students and less on the ‘Difficult science’ sub-scale. Also related to these conclusions is the correlation data (Table 4.12). Students who do not think science is difficult are the same students who score highly on the other attitudinal and interest scales.

In this study 13.6% of students’ responses to “a bad thing about science” were coded in the category ‘(science is) too difficult’; apart from comments worded in this manner, other comments relating to this theme were “you have to be smart to do science” or “I don’t understand half the stuff that I am told” and “teachers’ scientific talk confuses you” (Table 4.14). This type of comment could reflect the fact that the scientific curriculum traditionally has been designed to recruit the scientific elite into a career in science (Tytler, 2007a) (see also teachers’ comments under ‘scientifically elite’ below). It is also important to be aware when analysing written responses that the students might use the word “difficult” when they are referring to the frustration of memorization, the large amounts of writing involved with the copying of notes, or the way science is presented rather than the “intellectual challenge” of the subject (Lyons, 2006, p. 603).

In the ‘Difficult science’ subscale, scores suggest that most students are ambivalent about whether science is difficult or not (scores are mid-range on a 3 to 15 scale) with
students split as to whether you have to be clever to do science (1.69; SD 0.8) or that science is too difficult (1.57; SD 0.8).

c. The Teacher and Science Attitudes

Hasan (1985), in his study with secondary students in Jordan, found a relationship between students’ perception of their science ability and their attitude to the subject. Hasan discussed how care should be taken by teachers to foster an “appropriate motivational atmosphere for their students conducive to healthy development of positive perceptions of their science abilities” (p.13). Osborne et al. (2003) stated that research evidence shows that “teacher variables” are the most significant factor in determining attitudes towards science, even more than “curriculum variables” (p.1070). Research into attitudes, interest, motivation and engagement, reveals that teachers or teaching practices are one of the major factors associated with these constructs (Fig. 2.1, Chapter 2). In this study responses to “a bad thing about science” included 26% teacher-related comments in secondary school but only 4% teacher-related comments in primary school (Table 4.14). There are also indications that secondary students prefer the teacher to facilitate rather than directly teach (see item means for ‘watching teacher do an experiment’ [3.08] and ‘teacher telling what to do’ [3.16]) (Table 4.2). As the number of classes sampled in this research project were relatively small even one ‘poor’ or unpopular science teacher is likely to have a strong effect on the students’ attitudes to science (Table 3.2). The following factors need to be taken into account when considering the results of this study:

- inexperienced teachers commonly teach the lower classes in primary school and the more experienced, competent teachers often teach the upper primary levels; and
- when entering secondary school students are sometimes placed into classes conducted by inexperienced science teachers, as was the case in the schools sampled for this attitudinal survey (Appendix H).

However it needs to be stated, that inexperienced teachers are not necessary less competent than experienced teachers.
d. Student-centred Investigations

In this study it is found that students' liking of independent investigation significantly declines from primary to secondary schooling (Tables 4.2 & 4.4). It is widely accepted by science educators that student-centred practical work, such as exploration and independent investigations, encourages student interest in science (Ebenezer & Zoller, 1993; Goodrum, Hackling & Rennie, 2001). Goodrum, Hackling & Rennie (2001, p. 155) found that in 59% of secondary classes the teacher never allows students to choose their own topics or to investigate. When carrying out the Case study during this research project it appeared that the classes at School C (Meadows Secondary School), where both the attitudinal survey and case study were conducted, were similar to the Australian classes described by Goodrum et al. (2001) where student-centred investigations were rarely or never carried out and in these classes the researcher observed theory science lessons which consisted of copying notes from the board (Chapter 5, 7 & Appendix H). This style of lesson was very different to some of the participant primary science classes where the children were given the opportunity on a number of occasions to carry out student-centred investigations or take part in independent research (Chapter 5, 7 & Appendix H). However it must be stated that in the opportunity class (6H) in year six, students were expected to copy extensive notes from the board (Chapter 5, 7 & Appendix H). If students had been given the opportunity in secondary school to regularly carry out student-centred investigations, where they were encouraged to question and discuss their results, in contrast to the 'teacher centred', recipe-style science practical lessons, and the large number of theory lessons, perhaps the scores for the 'Independent investigator' or the 'Science interest' sub-scales at secondary level would have been higher.

e. Negative Images of Science’s Role in Society

In this study students responded to the short answer questions with their feelings about both school science and world science. Millar and Osborne (1998, p.8), looking into the science curriculum in the UK, stated that as a result of the impact on the environment and society of the application of some scientific and technological discoveries such as the use of DDT, the causes of ozone depletion, and the public unease about genetic modification, the image of “science” has been tarnished. This view is evident in this study where, in the
short answer responses to a “bad thing about science”, there are comments from primary students such as “polluting the Earth”, “it can be used in war”, “results in our downfall”, and from secondary students such as “genetic modification”, “it makes me feel sad with all the issues raised” and “(science’s) bad reputation”. It was interesting to note that less secondary students thought that ‘science is good for everybody’ compared to primary students (P 2.32 to S 2.11) (‘Social context’ individual item, 3 point scale, Table 4.3).

f. Relevance of Science

Making science relevant to the students’ own world is one of the key factors leading to student engagement and positive attitudes towards science (Tytler, 2007a). Millar and Osborne (1998, p. 9) discussed how the science curriculum in the UK has an over emphasis on content “which is often taught in isolation from the kinds of contexts which could provide essential relevance and meaning”. In her study in Sweden, Lindahl (2003) found that many students did not understand why they were doing science. The DETYA study (Goodrum, Hackling, & Rennie, 2001, p. 486) stated that, “science at school is engaging and challenging when it connects with students’ contemporary interests and experiences, but often this is not the case”. In his comprehensive longitudinal study in the UK (N=21; over years 7 to 11), Reiss (2000) stated, that if science education in schools is to succeed, it needs to relate to students on a personal level.

In this study a number of short answer responses from secondary students show similar views to those discussed above relating to the relevance of science; such as: “interesting in a way but not relevant to us”, “too much depth that we do not need to know”, “most things don’t interest you, we only need the basics”, and “difficult to understand and useless”. Although it is worth noting with regard to ‘science in society’ or ‘world science’ being more relevant to students than the science they are presented with in school, that only a relatively small number of responses referred to social issues relating to science as being either positive (16% overall: P 7%; S 9%) or negative (9% overall: P 4%; S 5%). The overall ‘Social context’ mean scores were high (about 20; maximum 24) although there was a significant drop from year six to seven (20.5 to 18.6). It is also worth considering that where significant group differences were noted (in year five and 10) males perceived...
the 'Social context' of science more positively than females; high ability secondary students also perceived the 'Social context' more positively than students of lesser ability.

**g. Science as Dull**

Millar and Osborne (1998, p. 10) discussed how the lack of variety in teaching and learning results in science lessons being "dull and uninspiring". This could be related to Osborne and Collins' (2000 p. 30) study looking at pupils' and parents' views of school science in England: they believed the science curriculum is "content dominated and assessment-driven and too homogenous" and felt that the teachers often rushed their students through the content reducing the opportunity for the students "to engage in practical work", take part in discussion or the "exploration of contemporary issues in science". When looking at the decline in numbers of Australian students choosing science subjects in senior high school or pursuing careers in the subject, Tytler (2007a) stated how science needs to be 're-imagined' to motivate and engage students. In this study about a tenth of the sample (9.5%) of both primary and secondary students commented about science being boring (although it needs to be stated that the word 'boring' can have different meanings such as the activity is difficult or it is unchallenging [baird et al., 1990]); even more noticeable is that the 'Science enthusiasm' scores fell from about 15 to 12 across the divide, and stayed at this level except for year eight. These scores are very low (maximum = 24) and Table 4.3 reveals that secondary students have little interest in doing science at home (1.28), science stories (1.33), science compared to other subjects (1.46), wanting to be a scientist (1.59) or being part of a school science club (1.59); in fact going to the moon is the only one of 9 items that scores a mean greater than 2.0.

**h. Science for the Intellectually Elite**

A secondary teacher (in this study) stated; "I think science is perceived as difficult for students because right from when they are little any social thing that they do, even movies or whatever, scientists are seen as the 'intellectual elite' and I guess a lot of these kids start to try and sort themselves out and if they don’t see themselves as intellectually elite they are going to display less interest and less application to something that they see as maybe too difficult for them (the students) to achieve". Even a cursory overview of the media’s presentation of science and scientists would tend to support such a view. With a number of
students perceiving science as ‘too difficult’ (Table 4.14, 13.6%) perhaps these students believe science is for the intellectually elite. Can teachers and the curriculum counter such outside influences?

4. Are These Results ‘Science’ Specific?

One difficult question that ‘interest’ research raises is, do students feel similarly about all subjects? Responses to the ‘Science enthusiasm’ item, ‘I like science more than any other school work’ suggest that science is not most students’ favourite subject: an analysis by year (range 1.26 to 1.54, i.e., disagreement with the statement) indicates a significant drop at the year six (1.63) to 7 (1.26) interface. There is an interim, but not significant, resurgence in interest in year eight (1.44). This interpretation is consistent with Lindahl (c. 2003) who found Swedish students had more positive attitudes towards other subjects. She reported that new secondary students found the physical sciences “so strange, difficult and serious all at once” (see year seven ‘Difficult science’ scores earlier) whereas other subjects “started like a game and the difficulties came gradually”; further they found science lessons “predictable” in their pedagogy compared to some other subjects. She concluded students “want to have more influence on their (science) learning like they have in other subjects” (p.13).

5. Responses to Research Questions and Assertions regarding this Attitudinal Survey

Responses to Research Questions

The research questions being addressed in this attitudinal survey are:

1. Do children’s attitudes towards science change over the primary/secondary interface?

2. What factors (year level, sex, ability) appear to be associated with any observed changes?

Although this is a relatively small study most of the findings support other literature. In response to the research questions the following assertions are made:
Chapter Six

Assertion 1

Students' attitudes towards science do change as they progress from year six, primary school into year seven, secondary school.

This was evident in all the subscales, namely 'Independent investigator', 'Science enthusiast', 'Social context' and 'Science interest'; also year seven students thought science was more difficult. (Research question 1).

Reasons for this decline are suggested in the responses to the individual items in the sub-scales and the open questions. Secondary students, although still liking the practical aspects of science, are less enthusiastic about making 'investigation' decisions; it would seem that they also would prefer teachers to facilitate more and 'directly teach' less; these two aspects could be related. Further, these students also are less interested in science pursuits (reading, TV, science as a subject relative to other subjects) and, although noting the role of science in technological advancement more, they are starting to doubt the role of science in society and are more ambivalent about whether science makes you think. With reference to increasing 'Difficult science' sub-scale scores, secondary students believe they are required to do too much science at school and too much writing in science; open responses also indicate that this could relate to the relevance of some science content. The item responses do not directly refer to the impact of the teacher but about a quarter of the secondary responses to the open-ended questions could be interpreted as teacher-related.

The decline in attitudinal sub-scale scores only occurred for girls and students of lower ability on three science subscales but was also present for students of all ability levels for the composite 'Science interest' scale. Once in secondary school, scores for the overall year cohorts, for the various sub-scales remain stable up to year ten. These scores are also generally stable for boys and girls and students of all abilities across these years, but there are some individual year differences for some scales for girls and students of lesser ability, and in one instance ('Social context') for higher ability students. (Research question 2)

Reasons for these variations are probably embedded in the suggestions made for the overall changes across the primary/secondary interface (see research question 1 above).
Further analysis of individual items for these different subgroups (male or female; ability or year) may provide more answers. It was noted that far more, lesser ability females referred to the difficulty of science in responses to the open ended items.

Research question 2 referred to changes across the sectors and years. Analyses within each of the sectors and years also were completed. These indirectly also address this second research question.

**Assertion 2.**

In general there were no male-female differences in science sub-scale scores, although males scored higher than females on some scales in Years 5 (3 scales), 9 (2) and 10 (1).

**Assertion 3.**

Higher ability students scored higher (lower for ‘Difficult science’) than lesser ability students on some sub-scales at all year levels, except year eight, in the secondary school (two in year seven; all in year nine; and four in year ten). These differences were not apparent in the primary years.

**Assertion 4.**

These data suggest that as students progress through secondary school there is an increasing tendency for lower ability students to lose interest in science. There does not appear to be an obvious gender effect (research question 2).

**6. Implications from this Attitudinal Study**

Implications from this study must be tentative. Some suggestions have already been made. Two issues will be briefly highlighted.

*Tackling the Problem of Movement Across the Primary/Secondary Interface*

In this study ‘Science interest’ (and two of its components) declined at the interface and then remained stable through to year ten (a plateau effect). As previously indicated other studies have noted the problems associated with movement across the primary/secondary interface, but many also recorded a continuing decline with advancing secondary years.
(Baird et al., 1990; George, 2000; Simpson & Oliver, 1985, 1990). There also were no year five or six differences noted here, and it is unknown if they have fallen from previous years (Murphy & Beggs, 2003; cf. Pell & Jarvis, 2001).

Clearly, if this research is symptomatic of other schools, then attempts must be made to ensure there is a smooth transition from primary into secondary science. Such a problem has been evident for more than 30 years (Harlen, 2003b, Skamp 1980). Fortunately Galton et al. (2003, cited in Harlen, 2003b) were able to identify good practice in schools where “pupils attitudes improved appreciably in year seven” (Harlen, 2003b, p.2). Primary Science Review (the primary science journal of the British Association for Science Education) devoted an issue in 2003 to articles discussing “effective transition” (Harlen, 2003b, p. 2), for example:

- ‘bridging projects’ in which there was a meaningful transfer of formative assessment across the primary/secondary interface and the development of trusting relationships between the primary and secondary teachers of science (McMahon & Davies, 2003);
- ‘transfer projects’ where a common science theme was used by teachers in the final term of year six and the first term of year seven. The theme of ‘Monsters’ is described (Brennan, 2003);
- continuing professional development that was required to meet the criterion of collaborative working between teachers across school sectors (Richardson, 2003);
- using science clubs to encourage primary and secondary students and teachers to work together, for example, in encouraging students to enter science competitions or in having a joint primary/secondary meeting with a real scientist; and
- having ‘taster days’ (e.g., ‘crime day’, ‘space day’) in which primary students go to the secondary school with a clear focus for the day (Chapman, 2003).

The success of these initiatives supports time being taken out by primary and secondary schools and teachers, to engage in cross-sectorial projects related to smoothing the science transfer at the interface. However, improving interest, motivation and engagement, in science, is influenced by many factors (curriculum, pedagogy, peer culture, assessment practices, home support, school ethos) (Harlen, 2003a) only some of which may be
addressed by such projects. There is also a risk that ‘taster days’ at secondary school for primary students may lead to unrealistic expectations of secondary science. To establish a smooth transfer from primary into secondary school a collaborative effort needs to occur where innovative science is presented in both primary and secondary schools as the disillusionment with science often occurs in secondary school. Syllabus committees, schools and teachers need to work together to address these factors.

**Considering Lesser Ability Science Students**

This study found that female students not in the high ability science group might be most susceptible to losing interest in science. One way forward may be for teachers to focus more on affective rather than cognitive strategies (Alsop & Watts, 2003). This has had a positive effect on some lower ability students’ confidence to do science (Yung & Tao, 2004), which may then increase their interest in the subject. Another suggestion might be to reflect on the amount of testing that is used in secondary science classes as “lower ability pupils are doubly disadvantaged by tests” as it impacts on how they feel about their ability to learn and further lowers their self-esteem (Harlen, 2003a, p.4; this paper also summarises the actions that research indicates teachers could do ‘more’ and ‘less’ of in relation to assessment in order to enhance motivation for (science) learning). Lindahl (c.2003) proffers that teachers need to make sure that they do not convey a “hidden message” which makes students feel “incapable and lacking in understanding”; she indicates that this would apply across all ability groups as even the “best (students)” in her study did not feel as if they were doing well (p.22). It is difficult to determine how the teachers impacted on the students’ perceptions of their own abilities in science in this attitudinal survey. The attitudes of the teachers in this study may have inadvertently given students a “hidden message” such as that described above by Lindahl, resulting in these students feeling inadequate with their ability in science and perhaps decreasing their interest in the subject (maybe with female students of lesser ability feeling more “incapable and lacking in understanding of the subject” p. 22). This feeling of inadequacy, could also have had an impact on the students’ ‘self esteem’ in science which is an important factor impacting on the constructs of attitudes, interest, motivation, and engagement (Fig 2.1, Chapter 2).
Conclusions

This study supports other science education literature revealing a marked decline in students’ positive attitudes towards science as they move from primary school into secondary school, and that students of lesser ability are more likely to lose interest further as they progress through secondary school. These findings reinforce the need to address this problem and investigate further to reveal the factors that lead to this decline. Recent research is highlighting the urgency of this problem (Holbrook, 2007; Tytler, 2007a). As one of the secondary teachers said: “I think it would be good if it (science) was more applied in some ways (so that) they (students) could see the relevance (of science) more, (but) I don’t know how.” Simply being aware of the issue is a start: this study, although relatively small in scope, is one step in that direction. Having suggestions for possible ways forward is important. Another signpost is to listen to what the students say and talk to them about their views.

However, there is probably no “miracle” solution to the decline in ‘Science interest’ (Rothapfel, 2004) and research “has had little to say definitively about how the problem might be remediated” (Osborne et al., 2003, p.1073). However there are messages emerging in the research literature and Osborne et al. provide a review of these. Although there are system (e.g., syllabus requirements, adequate resources for teachers and students) and school variables (including initiatives across the primary/secondary interface) that impact on students’ interest in science, many studies have concluded that it is the kind of science teaching students experience that is most important. The impact that science teachers can have on student interest cannot be overlooked as one of them most important variables (Fig. 2.1, Chapter 2). Further, affect must always be uppermost in teachers’ minds: Claxton’s (1989, cited in Alsop & Watts, 2003, p.1043) words sound a warning: “Cognition does not matter if you’re scared, depressed or bored”.

If interest in science is a key variable in determining students’ choice of subjects in senior school and university then it is essential that additional effort is made by educators to ensure the science classroom environment not only interests but, motivates and engages students, allowing them to explore, investigate, discuss, and debate, issues, that relate to their own world and to science in the 21st Century. The following Case study attempts to
look through the eyes of the students in order to determine factors that ‘switch them on’ to science and sustain an interest in the subject.

**The Following Chapter:**

The results of the case study and how the results relate to literature are discussed in Chapter 7. The findings from this attitudinal survey are useful in giving an insight into a wider cross section of students’ attitudes to science within the school community accessed in this study.
CHAPTER SEVEN

CASE STUDY OF SELECTED STUDENTS: DISCUSSION OF FINDINGS AND IMPLICATIONS FOR SCIENCE EDUCATORS

Overview

This chapter discusses the findings of the case study. The effect of the research (‘Hawthorne effect’) is discussed and its implications are highlighted. Other factors, which assist in understanding the participants’ attitudes to, and interest in, science, are outlined and variables such as perceived difficulty, gender, ability, parental attitude and social involvement or peer support are considered. A number of assertions relating to the findings are included and finally a summary of the findings and implications for educators are presented. The chapter is organised under the following headings:

1. attitudes towards, and interest in, science over the primary/secondary interface years: years 6 and 7 in general and the participant students in particular;
2. retention of interest in science by most participant students: a ‘hawthorne effect’;
3. particular factors, which assist in understanding the participants’ interest in science and sources of their interest;
4. other variables relating to this case study;
5. students with a passion for science and listening to the students’ voice;
6. response to the research questions; and
7. summary and implications for educators.

1. Attitudes Towards, and Interest in, Science over the Primary/Secondary Interface Years: Years 6 and 7 in General and the Participant Students in Particular

Numerous attitudinal studies show a decline in positive attitude towards science over the primary/secondary interface years (Baird, Gunstone, Penna, Fensham, & White, 1990; Braund & Driver, 2005; Ferguson and Fraser, 1998; James & Smith 1985; Jarman, 1990; Keogh & Naylor, 2004; Simpson & Oliver, 1985). Both the ‘snap shot’ attitudinal study, across years 5 to 10 carried out in 2004 from which this case study’s participants were selected, and the attitudinal survey, which was repeated in 2005 with year seven non-participant students, followed this trend. In contrast to this, the study participants in this
case study, as a group, remained generally positive towards science, with one student becoming considerably more interested in science in year seven and a number of students possibly maintaining or developing a ‘personal interest’ in science as they moved from primary school into secondary school. However, there were several participant students whose interest did decline across the primary/secondary interface. These findings were supported by the quantitative and qualitative data. The results reveal how the mixed methods of data collection have allowed ‘cross-validation’. In the majority of cases the quantitative data supported the qualitative data for the students, as individuals, and as a group. The analysis of these data has allowed the researcher to gain a glimpse of how these 20 students perceived science in society and school science. Aspects that ‘sparked’ an interest in the subject and led to motivation and engagement together with aspects that ‘switched students off’ science were revealed. However some of these methods of data collection could have lead to the ‘Hawthorne Effect’, as outlined in the following section.

2. Retention of Interest in Science by Most Participant Students: A ‘Hawthorne Effect’?

There was no significant difference in the mean ‘Science interest’ scores of the study participants and non-participants’ in year six, whereas in year seven a significant difference became apparent (Table 5.5 and Table 5.4, Chapter 5). As the non-participants’ scores revealed a decline in positive attitude and the participant students’ scores remained stable over the primary/secondary interface, it is possible there was a “Hawthorne effect” where the participants saw themselves as special because they were chosen to take part in this research project and were receiving special attention from the researcher (Smith, 2003, p.114).

The researcher may have influenced student interest by a number of factors and questions relating to these factors are included for contemplation. The following section outlines these factors and is organised into the following subsections:

a. giving credence to student voice;
b. self-esteem at science and motivation towards the subject;
c. helping students see the value in school science and ‘personal interest’ in science;
d. bridging the primary secondary communication gap; and
e. the ‘Hawthorne effect in this study.
a. Giving Credence to Student Voice

During the year six teacher interviews (2004) most teachers remarked on the high level of enthusiasm of the participant students towards the study; for example, a number of year six participant students were eager to discuss their own scientific investigations with the researcher and show her their journal entries as soon as she entered the school grounds. As previously mentioned according to the attitudinal study conducted in the early months of the research project in 2004, these students, as a group, did not score higher ‘Science interest’ scores than the other students in year six. Each individual student had been chosen to take part in the study and was given the opportunity to express his or her thoughts and feelings towards the subject. The students’ attitudes and opinions were taken seriously. The students were also aware and appeared very enthusiastic about the fact that some of this data was to be published. The ROSE study sought to give students ‘a voice’ (Jenkins & Pell, 2006). According to Jenkins and Pell (2006, p.4) by listening to students’ interests and beliefs, and responding to their needs, the ‘alienation’ that is felt by some students from their schooling could be reduced, thus addressing other problems associated with this alienation. A web-based survey in England was a great example of students being given a voice in science (Murray & Reiss, 2005). This survey involved a group of 350 students (aged from 16 to 19 years) who designed and implemented a web-based questionnaire relating to their school science curriculum that was completed by a further 1,479 students aged from 14 to 19 years. Data from this survey were included in a report by the Parliamentary Select Committee on science and technology in England, reviewing Key stage four science. Murray and Reiss discussed how the select committee, the students involved in the project, and those funding the student review, were delighted with the outcome of this project where young people had been consulted and had their ideas taken seriously (p. 92).

b. Self-esteem in science, peer support of other participants, and motivation towards the subject

‘Self-esteem’, ‘peer support’, and ‘motivation towards the subject’ are common factors related to student attitude, interest, and engagement. ‘Self-esteem’ and ‘peer support, are also factors related to ‘student motivation’ (Fig 2.1, Chapter 2). Did these participant students become more confident about their opinions towards the subject as a result of
having their ideas taken seriously in this study and/or did participation in the study or feeling special and part of a peer group enhance the students’ self-esteem towards science? Maybe these students felt more motivated towards science as a result of taking part in the study?

c. Helping Students See the Value in School Science, Seeing Positive Aspects of Science and developing a Personal Interest in science

Simon (2000) highlighted the importance of being aware that when a student displays interest in science it does not necessarily follow that he or she will have a positive attitude towards science as a school subject. The qualitative data in this study generally supports the quantitative data in that the majority of students appeared to have maintained their interest in science per se. The qualitative data also revealed that students in this case study had a positive attitude towards school science and to science in society. The majority of participant students (14 [of 20]) saw the relevance of school science and how it related to science in society and this will be discussed further below (see ‘relevance of school science and science in society’).

The study of attitudes in science is very complex and is influenced by numerous variables. Simon (2000) identified, “the value of science” amongst other variables that influence an individual’s attitude to science including, self-esteem, attitudes of peers, and motivation towards the subject (p. 105). Could these participant students have started to see more clearly, the value of science as a result of clarifying their thoughts about the subject? Perhaps the students co-constructed their knowledge as a result of participating in discussion during interviews and focus groups.

An interesting strategy relating to Leon Festinger’s ‘cognitive dissonance’ theory was proposed by Misti and Shrigley (1994). This strategy involved incorporating moments of “dissonance” during learning processes in science, such as asking the students to write “pro-science” essays (p. 8). Students who were positive about science would be reinforcing their own views but those students who were negative about science generally were encouraged to look at science from a different point of view. The theory behind this strategy was by taking part in an activity such as this, students would become aware of positive aspects of science and this could influence their attitudes towards the subject.
During this case study students were asked in individual interviews, focus group sessions, and in surveys, to list aspects of science that they liked. Could thinking about the positive aspects of science also have influenced their attitudes?

Most of these students were interested in science generally, and they displayed motivation towards, and engagement in, aspects of school science. They developed an interest in science in society and were aware of the value of school science. A number of students clearly developed what is termed a “personal interest” in science (Hidi, 1990, p. 551). Is there a possibility that participating in the study enhanced or maintained this ‘personal interest’ in science over the primary/secondary interface?

d. Bridging the Primary Secondary Communication ‘gap’

After the students had moved from primary into secondary school the researcher who had established a relationship with the students in primary school was once again there to listen to the students discussing their attitudes and feelings towards science. Jarman (1990) stressed the importance of effective communication between the teachers of primary and secondary schools, to assist in the process of movement across the primary/secondary interface. Braund and Hames (2005) developed bridging courses providing a link between primary science and secondary science that have resulted in students maintaining positive attitudes towards science over the primary/secondary interface. Could the researcher have inadvertently provided a link and communication between primary science and secondary science?

e. The Hawthorne Effect in this Study

Sometimes intervention as a researcher is unavoidable in a research project (Arnold, 2006). In some research projects this ‘Hawthorne Effect’ could be seen as a threat to the validity (Smith, 2003). However, in this case study, giving students attention and listening to their opinions might be a useful strategy used by teachers to improve students’ attitudes towards, and interest in, a subject in a classroom situation (Hanrahan, 2006). It is important to note that, although participation in this study appeared to affect students’ attitudes to, and interest in, science, it will not be known until the students’ year ten data is analysed if
students maintain these attitudes and interests through junior secondary school. Even though this study is from a small sample and cannot be generalised the variables discussed above may have impacted on the students’ attitudes towards, and interest in, science, or even enhanced or maintained a ‘personal interest’ in the subject. As they are consistent with some of the literature they should not be overlooked as ways of understanding the observed results.

3. Other Factors which Assist in Understanding the Participant’s Interest in Science and Sources of their Interest

The following section is a discussion of factors, which assist in understanding the participant’s interest in science and sources of their interest:

a. teaching quality, classroom pedagogy and environment;
b. practical science;
c. student-centred practical science;
d. writing notes in science;
e. learning new things in science;
f. discussion and argumentation in science;
g. relevance of school science and ‘science in society’;
h. Information Communication Technology (ICT) and interest in science;
i. multi-modal representations of science; and
j. choice of topics.

a. Teaching Quality, Classroom Pedagogy and Environment

This study’s findings are supported by the Australian government’s DETYA study of science in primary and secondary schools (Goodrum, Hackling & Rennie, 2001). It reported that where primary science is taught in Australia, it is often very practical and student-centred providing opportunities for the students to independently investigate, resulting in “high levels of student satisfaction” (p.154). Student-centred science where the students were encouraged to independently explore and investigate was common in this case study in the primary schools (as revealed during classroom observations, interviews and focus groups). Goodrum, Hackling & Rennie (2001) described two types of science lessons in Australian secondary schools: teacher-directed practical lessons and “chalk and
talk” style teacher-directed theory lessons where the students spend time copying notes, listening to the teacher talking or working from a text book (p.155). Student interviews, focus groups and classroom observations during this study in the secondary school revealed a very similar picture in most of the secondary classes where science lessons were teacher-directed and consisted of both the theory and the practical lessons as described by Goodrum et al. In contrast to many primary schools in Australia, in the United Kingdom it appeared that in the late 90’s the more traditional secondary style science lessons like those described above (Goodrum et al., 2001) were found to occur in primary classrooms, where teachers did all the talking and the students were encouraged to sit still and listen (Galton, Hargreaves, Comber, Wall & Pell, 1999). This was thought to be a reaction of teachers to the National Curriculum demands. However this change in teaching style may have been a factor impacting on primary students’ attitudes to science in the United Kingdom, where they have been found recently to become less positive to science in late primary school (Jarvis & Pell, 2001).

The change in student/teacher relationships that occurs when students move from primary school into secondary school, outlined by Fraser (1995), could also be a factor influencing the students in the case study (and also the attitudinal surveys) whose attitudes to science became less positive over the primary/secondary interface (see Chapter 5, under ‘participants as individuals’ and Results chapter 4).

When looking into research relating to the constructs attitude, interest, motivation, and engagement, pedagogy was revealed as one of the most important factors influencing these constructs (Fig. 2.1, Chapter 2). Teaching quality is seen as one of the important factors relating to students’ attitudes to science (Brok, Fisher & Scott, 2005; Ebenezer & Zoller, 1993; Woolnough, 1994) and it can influence students with their decisions to pursue the subject in senior secondary school (Woolnough, 1994). The English students highlighted, in their review of the science curriculum, the importance of “good science teaching” (Murray & Reiss, 2005, p. 92). These students discussed how “learning is helped by having a teacher who can engage with students and by the use of visually stimulating material” (p. 92). According to Rothapfel (2004), science teachers should be committed to giving students a positive experience of science in order “to ensure a love of learning in science” and should seek to create an environment that is comfortable and leads students to
continue with science throughout their schooling (p.25). Some teachers may unconsciously alienate students by their communication methods (Hanrahan, 2006). White (1988) discussed how a student might experience positive ‘episodes’ in science lessons with interesting activities that relate to the student and resulting in the student forming a positive attitude towards the subject. However, negative episodes can change a students’ attitude to science, for example, being unjustifiably rebuked by a teacher (p. 107). It is important for teachers to interact with their students in order to create an environment of “mutual trust and respect where all students can feel included” (Hanrahan, 2006, p. 4). It is only by being consistent with this careful interaction where dialogue is encouraged and students’ interests and cultural backgrounds are considered, that students will “feel included as legitimate science learners” (p. 8). Qualities that university students identified as being important for teachers of early secondary school included: “makes lessons fun and interesting, has the ability to explain things clearly, is enthusiastic towards science, has a sense of humour, is friendly and approachable has a good understanding of the content and is kind and helpful” (Palmer, 1999, p. 44).

In the 2006 Australian Council for Educational Research (ACER) conference, science educators called for “an urgent re-thinking of the way science is taught in Australia” to address the problem of the decline in student interest in science (Ainley, 2006, p.1). In order to address these important issues such as, the lack of relevance of science, the declining numbers of students choosing science subjects in senior school, and fewer students pursuing science careers, it is vital that teachers adopt innovative pedagogies, knowledge and commitment to science. Support is necessary for teachers to assist them to develop these innovative practices such as focussing on enquiry and reasoning, giving students more choice of topics, encouraging discussion and debate, making science more engaging and more relevant to science “in real life” (2006, p. 1). These science educators also believed there was a need for teacher training to be creating engaging and dynamic teachers in science.

The teachers’ personality and teaching qualities cannot be overlooked in this case study as being important factors impacting on the students’ attitudes. It is evident from this study that qualities recognized as being those that promote enjoyment of the subject were lacking in the teachers of 7K and 7H:
• students of 7K clearly disliked the large amount of teacher-directed theory in their
class in contrast to 7L where students remarked on the large number of practical
lessons and enjoyed the fact that they had notes printed for them instead of
extensive 'copying of notes'. There were other aspects that frustrated some students
in 7K such as the high expectations by the teacher for the students to be exact with
scientific drawings and report writing, the heavy use of the text for science theory,
unclear explanations, lack of time to thoroughly understand the information, being
told to go and find the answers, and feeling humiliated by the teachers’ comments
towards their responses during teacher/student discussions (Appendix H, narratives
of schools, classes and teaching styles). The students in 7K seemed to have a
reduced interest in science and six (of 7) increased their ‘Science difficulty’ sub
scores. (Rushing through topics and lack of clear explanation were responses
recorded by students in the attitudinal survey, for "a bad thing about science" in
secondary school);

• the students’ frustration at the lack of practical science and boredom with the chalk
and talk style of presenting ‘science theory’ was also clearly evident in 7H,
although these students’ ‘Science interest’ scores remained stable over the
primary/secondary interface; and

• the female students, who remarked on how the practical sessions in year seven were
teacher-directed, were from classes in year six, where they had experienced student-
centred science, with independent exploration activities and investigations
involving fair tests where the students could form hypotheses.

In his list of features that are common in classroom environments with exemplary
teaching, Fraser (1995) included: relaxed atmosphere; classroom environments that are
favourable to students; pleasant interactions with students; subtle humour with students (in
contrast to the cynical humour occurring in 7K); elicitation of students’ understanding of
scientific concepts; and respect for students’ ideas (p. 518). These practices did not appear
to be occurring in 7K or 7H.

Many of the comments in this case study mirror those comments made by students in
studies from different countries outlined by Lyons (2006). Lyons compared three studies,
relating to school science from the United Kingdom, Sweden and Australia. In these
studies science was presented in a ‘chalk and talk’ fashion and students were encouraged to sit still and copy notes. Lyons stated that the students in these three different countries described their school science pedagogy as “the transmission of content from export sources – teachers and texts – to relatively passive recipients” (p. 595). The following examples reveal a similarity between comments from students in Australia and students in the United Kingdom relating to their school science experience.

Kara from 7K: “I don’t like theory, like writing in our books, it sucks, cause you, like, if you stop for a second then you have heaps and heaps of stuff to do, cause they just keep writing it is really annoying and I don’t like writing” (case study reviewed in this thesis).

Charlie: “A lot of what we do is just copying stuff from the board, so it doesn’t really connect” (Lyons, 2003 p. 107) (Lyons study in Australia).

Jake: “Some teachers just read off a page and you’ve got to copy it down and they don’t say anything about it, and you’ve got a page of writing in your book and you don’t know what you’re doing. (Osborn & Collins, 2000, p.27, as cited in Lyons, 2003, p.595)

‘Practical science’, student-centred practical work, and writing in science are discussed further below, as well as additional information relating to classroom environment and pedagogical factors.

\textit{b. Practical Science}

Generally practical work is very popular with students (Cleaves, 2005). The English students in their review of their science curriculum recommended, “practical science should be strongly encouraged and relevant to the syllabus” (Murray & Reiss, 2005, p. 91). In a study by Braund and Driver (2005, p. 83) students preferred practical work to written work and reading in science as they found it “fun, enjoyable and motivating”. The students in this case study are no exception, using words such as “fun, interesting, fascinating and cool” to describe practical science. In fact the majority of students observed by the researcher participating in practical science generally displayed motivation towards, and engagement in the activities. In a New Zealand study in a girl’s secondary school, where students became more positive towards science over the primary/secondary interface, it
was apparent the units were organised to provide a large amount of practical work and a variety of activities (Whitten, Tuck & Haigh, 2003). University students training to be primary teachers took part in a study where they were asked to list attributes that they believed made “the best” science teachers (Palmer, 1999, p.42). Common responses in the written surveys and group discussions involved teachers who made science lessons “interesting” (or fun), provided regular ‘hands-on’ science, which related to the science theory that was being presented, and gave clear explanations (p. 44). Although practical work does not necessarily lead to improved, conceptual learning in science (Harlen & Wake, 1999), each participant student in this study stated that practical science or experiments were an aspect of science that they liked in both primary and secondary school. Seven students said that they could understand ‘things in science’ more clearly (assumed to mean conceptual ideas of science) when they were able to take part in experiments or practical science.

**c. Student-Centred Practical Science**

Goodrum, Hackling and Rennie, (2001, p. 155) found that in 59% of secondary classes the teacher never allows students to choose their own topics or to investigate. Ebenezer and Zoller (1993) believed that student-centred practical work, where students were encouraged to independently experiment and explore, design their own fair tests and take control of their learning, encouraged ‘interest’ in science and allowed the students to build on their prior knowledge (in contrast to teacher-centred practical science where students follow the teacher’s recipe like instructions for science experiments and are often told the results of the experiment before performing it). This case study supported Ebenezer and Zoller’s findings as a number of students in this study discussed how they enjoyed taking part in student-centred practical science in primary school, where they carried out fair tests and formed hypotheses. Six female students commented on how there were less student-centred practical activities in secondary school and three of these students stated that they preferred science in primary school. Evidence of these classroom attributes, which were observed during some of the primary science lessons in this study, were rare in the secondary classes (for further information about secondary science classes see, 2b(i) ‘The impact of specific classroom environments’, Chapter 5, and Appendix H). Teacher demonstrations (rather than student-centred practical lessons where students were
encouraged to investigate and explore) and being told the results of an experiment by the teacher before actually performing the experiment, were practices that were particularly disliked by students in both the case study and the attitudinal survey.

**d. Writing Notes in Science**

In a the classes involved in a study where the students (girls) remained positive towards science over the primary/secondary interface, copying of notes was kept to a minimum (Whitten, Tuck and Haigh, 2003). All year seven students in this case study revealed their dislike of ‘writing’ in science and a number of students complained about the large amount of ‘copying of notes’. Goodrum, Hackling and Rennie’s study (2001, p. 155) revealed that 61% of secondary students indicated that they ‘copy’ notes most lessons. There was a noticeable difference in the amount of theory and practical science activities presented in classes in secondary school and some teachers appeared to present considerably more theory which consisted of copying notes from the board or texts. In contrast to verbatim copying of notes, Hand, Wallace and Yang (2004) developed a ”science writing heuristic” (SWH) (p. 131) for use with secondary students. They found the use of this heuristic, encouraged the teacher to adopt a student-centred approach. This approach involved students taking more ownership over their practical activities as it required them to think about their hypotheses, observations, claims that they were making and evidence that they were examining. They were then asked to read up on these ideas and reflect on how their ideas had been challenged, changed or supported. With the implementation of these science writing heuristics, Hand et al (2004) aimed to encourage teachers to assist students in constructing understanding of concepts in science. They found that using the SWH allowed teachers to move past the recipe-style practical science lessons, which are so common in secondary school, and its use encouraged students to be in control of their own learning. Students who used this writing heuristic as part of their laboratory activities enjoyed the opportunity to frame their own investigation questions and believed that they became more engaged as they were answering questions relevant to what they were interested in. The students who had used the heuristic during practical science lessons and completed a writing task as part of a summary of the topic, outperformed other students who had undertaken typical ‘recipe style’ science practical lessons, in a topic test (Hand et al).
Chapter Seven

Narrative writing is an effective method of communicating science ideas as highlighted by Rigano and Ritchie (2006). In a study that they conducted with a class of year four students in Australia in 2005, the students worked collaboratively to write a “mixed genre fictional story”, with illustrations based on a marine science topic (2006, p. 2). The study found that the students’ writing scripts and illustrations displayed accurate understanding of science concepts (2006, pp. 5,6). As authors and illustrators of a book published as a result of the study, these students felt “an interactive relationship with the scientific world” (2006, p. 13) and would most likely have felt a sense of pride and achievement. It was interesting to note that Alana and Clay in this case study (Chapter 5) listed story writing as one of their favourite activities in primary school even though they both state writing notes in science is a ‘bad thing about science’. English, which generally requires a large amount of writing, rated very highly as a subject with students in both year six and year seven. Perhaps this particular dislike of writing in science amongst students generally is not the writing per se but the ‘mindless’ copying of notes (that is the problem here).

e. Learning New Things in Science

In a study looking at ‘situational interest’ in a science lesson, Palmer (2007b) revealed that learning (relating to learning new things in science) was the most important source of interest to the students. Palmer suggested that learning could be as a result of feelings of success (where taking on new information or understanding scientific ideas more clearly possibly created a feeling of success) as success was considered to be an important source of ‘intrinsic motivation’ (Lepper & Hodell, 1989, as cited in Palmer) and Palmer argues that success might stimulate interest in addition to motivation. This case study supported Palmer’s findings, as ‘learning new things in science’ was a common response amongst the female students and the high ability male students in this study as a positive aspect of science.

f. Discussion and Argumentation in Science

Student-centred science can be encouraged by providing opportunities for classroom ‘argumentation’, particularly scientific argument, as it allows students to “explain events in the material world” (Osborne, Erduran & Simon, 2004, p. 996). It is important for students
to become aware of the "strengths and limitations of scientific argument" by taking part in arguments that are "scientifically valid" (Osborne et al., 2004, p.996). There have been strategies trialled, for example, the use of concept cartoons and puppets, which suggest that argumentation can engage primary (Keogh & Naylor, 2004; Naylor, Keogh, Downing, 2007) and secondary students and hence retain their interest (Keogh & Naylor, 2004). In the student review of their science curriculum it was recommended that, "there should be more discussions in science classes. Discussions provide students with the opportunity to learn from someone other than their teacher and, healthily, to disagree with teachers and develop their own ideas" (Murray & Reiss, 2005, p. 92). Discussions and debates were rated by these students as one of the most effective teaching and learning methods of science (p. 86). Sjoberg's 2000 study suggests science is often perceived to be authoritarian and seldom encourages critical thinking or debate (as cited in Lyons, 2006, p. 597). It is suggested that if school science does not encourage critical thinking and promote discussion and argumentation, this may influence students in their choice of subjects in senior high school and they may be attracted to pursue other subjects where critical engagement is a strong aspect (Lyons, 2006).

In this study, 6H students were given the opportunity to debate and discuss subjects like environmental issues. A number of teachers mentioned during interviews how some participant students like to question and discuss aspects of science. Interviews suggested that several students enjoyed discussing science topics and issues. However the depth of the discussions and how much opportunity the students had in year six and year seven for scientific argumentation is unclear in this study, but classroom observations and interview data from this case study appeared to suggest it was minimal in year seven.

**g. Relevance of School Science and 'Science in Society'**

It is evident from the literature that students are finding school science lacks relevance to their lives and this appears to be a contributing factor to students' current lack of interest in the subject. Ebenezer and Zoller (1993, p. 183) found that issues relevant to the students' local situations and "relating science concepts to everyday life" were factors students identified as leading to a positive experience in science.
Chapter Seven

Aikenhead (1996, p. 13) believed that most students see “orthodox science” as having little or no relevance to their life. Student participants in a later American study stated that school science lacks relevance particularly chemistry and physics (Osborne and Collins, 2000). In Australia, Rennie, Goodrum and Hackling (2001) noted that much of school science lacks relevance to the students’ “needs and interests”. They concluded that only one-fifth of students find science lessons “relevant or useful” (p. 473).

Reiss (2000, p.144) considered that the existing science curricula in England and Wales did not allow students to “reflect on why they are learning in science what they are learning” and Lindahl (2003) found that many students in her longitudinal study of middle school students did not know why they were learning science. In a study looking at students’ perceptions of high quality science teaching 13% of participants stated that making science relevant was important (Palmer, 1999).

In a project funded by ASISTM (Australian Schools Innovation in Science, Technology and Mathematics) established by a team of academics from Monash University in Melbourne, a group of teachers from a number of different schools, established a network to improve student engagement in secondary science. One of the teachers involved in this project, where the problem-based learning approach was introduced, set up tasks where the students explored relevant science-based issues. These tasks included:

- discovering the impact of drugs on the human nervous system;
- simulation activities where students provided counselling to expectant parents with children identified as having genetically inherited diseases; and
- a project that involved integrating other Key Learning Area’s (KLA’s) where a presentation was developed to convince the Australian Prime Minister to take action on the Kyoto treaty relating to reducing carbon dioxide emissions.

A year later the students reflected on the projects and expressed how much they had enjoyed covering these issues in science (Smith & Mitchell, 2007). The student-centred learning pedagogy is clearly a factor in this example but it also suggests that topics that relate to the students’ lives can lead to students having a more positive attitude towards their science lessons.
Chapter Seven

In this case study, although one student did not know why they were studying science in school in year seven, most students saw the relevance of science in terms of future careers and the majority of students, particularly the girls, saw the relevance of science to life. This may help to understand why the group of students in this case study generally remained positive.

**h. Information Communication Technology (ICT) and Interest In Science**

Studies have revealed that using ICT along with practical and investigative work can lead to a positive experience and enjoyment of science (Murphy, Beggs & Carlisle, as cited in Murphy, 2003) and through simulations, computer modelling and internet research allow students to participate in activities relating to “science in the real world” (Webb, 2005, p. 728).

A number of students in this study discussed how they would like computers to be used more in science to reduce the amount of copying of notes, as tools to present science topics, and that computer software could be used in place of texts. The students also said how digital and video cameras could be used to record results of experiments. Scientific videos were also popular with some of the students in the study.

A number of high ability students stated their enjoyment of independent research on the Internet particularly in primary school and how they would have liked to participate in more research such as this in secondary school. However, they did sometimes note their frustration at not being able to access the information they were seeking. It was interesting to note in the student review of the science curriculum in England, 44% found researching on the Internet an enjoyable experience but only 8% believed that it was a useful and effective way of learning science (Murray & Reiss, 2005, p. 86).

**i. Multi-Modal Representations of Science**

It appears that in many cases science pedagogy is uni-modal where science is presented in a “chalk and talk” fashion with recipe style practical lessons, and this is particularly common in secondary schools (Goodrum, Hackling & Rennie, 2001). This style of teaching is evident in both the case study and the attitudinal survey and has lead to
boredom and frustration with the students, especially where copious amounts of copying notes is concerned (see d. 'writing notes in science', above). This uni-modal representation of science is in contrast to multi-modal representations of science including the use of ICT such as digital cameras and computer based programs (mentioned above under h. information communication technology [ICT] and interest in science) combined with other methods of representations of science such as role-plays, group posters, physical models, demonstrations and interactive whiteboards. These multi-modal representations of science are promoted by Tytler, Peterson and Prain (2006). They encouraged teachers to provide opportunities for the students to “question, explain, modify, and coordinate” these representations in order to clarify various science concepts and they believed that a representational rich learning environment provided students with the opportunity to construct and refine their knowledge with each mode of representation (p. 16). Integration of science with language arts activities was found to enhance scientific literacy (Rigano & Ritchie, 2006). In year six, when discussing what she would like to do if she was planning science, Leigh said “Why don’t they just show you an experiment and make you figure it out for yourself. If you see it you understand it more” (in preference to writing about or hearing the teacher talk about science concepts). This comment shows how Leigh would like to have more control over her learning and be able to question and explain. It suggests that interpreting visual representation can assist students in their understanding of conceptual information.

**j. Choice of Topics**

Jones, Howe and Rua (2000, p. 185) found that students generally supported the “gender-typic” patterns where males are more interested in physical sciences and females are more interested in the biological sciences. Osborne and Collins (2000) were surprised by the fact that boys as well as girls found aspects of biology interesting. This study followed the same pattern where both males and females stated their enjoyment of biology topics. Five (of 8) students from 6H (3 males and 2 females) particularly enjoyed taking part in individual projects involving the researching of animals and plants on the Internet and in books (Table 5.12). All classes in year seven covered topics involving animals and plants. These topics involved large amounts of theory and few practical sessions in most classes. Three year seven students (one male and two females) stated their enjoyment of
‘living things’ topics. However it was also noted by a student in year seven that there were large amounts of theory and a lack of practical activities during these topics. Three students would have preferred the teachers to make more use of the school grounds and live specimens when learning about living things, particularly as the grounds of the school include forested areas, native gardens and food gardens. Three students (one male and two females) enjoyed individual homework projects in years six and seven involving researching animals on the computer and in books and other resources (Table. 5.14). Strategies to orient topics (that are often unpopular) to capture students’ interests were discussed by Baram-Tsabari and Yarden (2005). Teaching physics in relation to space science, calculating the forces involved in lifting an elephant, or looking at inventions and patents to teach aspects of science (such as chemistry or physics) were some of the ideas suggested (Baram-Tsabari & Yarden).

4. Variables in Relation to this Case Study

The following variables are discussed in this section:

a. perceived difficulty of science;
b. science ability and interest in science;
c. the impact of gender;
d. parental influence; and
e. social involvement or peer support.

**a. Perceived Difficulty of Science**

Students tend to perceive that they have a low ability in science when they find science difficult and this negative perception can influence the students’ achievement, attitude and behaviour (George, 2006; Lindahl, 2003). Hasan (1985) found that students who perceive that they have higher science ability, have better self-concepts, and therefore are motivated towards achieving. In the attitudinal survey it was found that as interest declines, science is perceived to be more difficult (Table 4.12, Chapter 4). This correlation is supported, to an extent, in this study as all participant students whose ‘Science interest’ scores declined markedly over the primary/secondary interface (Table 5.6, Chapter 5), had an increase in science difficulty sub scores. Sixty one percent of participant students perceived science to be more difficult in year six than year seven (see Table 5.6, Chapter 5). There did appear to
be some relationship between science difficulty and class effect, as six out of the 11 students whose science difficulty sub scores increased were from 7K.

**b. Science Ability and Interest in Science**

Analysis of the participant students’ ‘Science interest’ scores showed no significant difference in the mean scores when high ability and mixed ability scores were compared over the primary/secondary interface. In Year seven there were three (of 11) high and three (of 9) mixed ability students who had ‘Science interest’ scores in the medium range (Table 5.6, Chapter 5).

There did appear to be some responses that differed slightly between the ability groups as more high ability (compared to mixed ability) students:

- stated ‘learning new things’ as ‘a good thing about science’ in year seven (Table 5.11, Chapter 5);
- could see the relevance of school science ‘for life’ apart from it being just for career purposes; they appeared to have a greater level of understanding of ‘science in society’ (see the responses of the high ability students compared to the mixed ability students in the section ‘Relevance of ‘science in society’ and of school science’); and
- may have shown a preference for ‘natural science’ topics although this may have been as a result of the various topics that were presented during the data collection period (Table 5.12, Chapter 5).

These views may be related to some high ability males retaining or increasing their interest across the primary/secondary interface (see ‘gender and ability differences across the primary/secondary interface’ in Chapter 5). However for these participant students links between ability and interest are tenuous and only one student, a mixed ability student, did not know why he studied science in school in year seven. The fact that the higher ability students did not reveal that they were any more interested in science than the mixed ability students in this case study, is an argument in favour of making science relevant for all students rather than for the purpose of recruiting the intellectually elite which has been the intention of the science curriculum in the past (Tytler, 2007a, p.3).
c. The Impact of Gender

Osborne, Simon and Collins (2003) stated that, of the factors influencing attitudes to science, gender is the most significant. Australian and international studies have indicated gender differences in students’ interest in, and attitudes towards, science (Martin et al., 2000), particularly during the late primary and early secondary years (Baird et al., 1990; Colley, Comber & Hargreaves, 1994; Ferguson & Fraser, 1998; Jones, Howe & Rua, 2000; Simpson & Oliver, 1985; Simpson and Oliver, 1990). A number of studies found girls losing interest more so than boys (Hendley, Parkinson, Stables & Tanner, 1995; Simpson & Oliver, 1985; Simpson and Oliver, 1990) but this trend has not been universal and the gap may be narrowing (Osborne, Simon & Collins, 2003). Whitten, Tuck, & Haigh (2003), in a primary/secondary interface study in New Zealand, with girls from an ‘all girls’ secondary school, found no decline in attitude towards science; in fact the girls’ attitudes towards science became more positive over the primary/secondary interface. Murphy & Beggs (2003) found Irish boys in primary school were less enthusiastic than girls about science lessons and experiments and Lindahl (2003) found boys to be as critical of science teaching as girls.

In the attitudinal study in both 2004 and 2005, there was no significant gender difference in the ‘Science interest’ scores of all year six and year seven students including the participant students in the case study (Table 4.8 and Table 5.9, Chapters 4 & 5). However in the attitudinal survey in 2004, there was a slight gender difference in years 5 and 9, where the boys scored higher ‘Science interest scores’ than girls. The qualitative data, however, indicated that:

- in year seven, seven (of 10) boys stated that they preferred science in secondary school compared to primary school and three (of 10) girls, stated that they preferred science in primary schools;
- more girls (9 [of 10]) saw the relevance of science for building their knowledge about their world or for living in this world than boys (5 [of 10]);
- more boys stated that they liked experiments involving Bunsen burners, fire and explosions. Girls only commented on the lack of student-centred practical activities in secondary school, such as investigations and being able to form hypotheses, and boys only commented on the lack of independent research in secondary school,
involving individual investigations or researching information from electronic sources or books; and

* the preference for other activity types (e.g., using ICT) and topics, the love of practical science and the dislike of writing notes appeared to be evenly distributed amongst the girls and boys.

**d. Parental Influence**

Parental or home support is a factor that is considered to impact on students’ attitude, interest, motivation and engagement (Fig. 2.1, Chapter 2). Andre, Whigham, Hendrickson and Chambers (1999) found parents of primary students perceived science to be more important for boys than girls and they discussed how the perceived importance of science by parents might influence the encouragement that is given to their children in science. From the results of the parental survey in this study there does not appear to be any apparent relationship between the students who became slightly less interested in science over the primary/secondary interface and the parents’ liking of their own experiences of school science. This supported George’s (2006) findings where there was no significant influence of parents on their children’s attitudes to science. However, the majority of students remained positive to science and the majority of parents who completed the survey appeared to like science in school. The parental survey used in this study (Appendix, C) asked parents, to express their feelings about their own school science experience, whether science should be a compulsory subject for children of all ages, and what sort of science they believed should be taught in primary and secondary schools. It might have given the researcher some idea of the parent’s attitude to school science in general but it did not give the full picture of how much support they gave to students with their science work or their schoolwork in general; therefore parental influence could not be ruled out. It is worth considering that perhaps as these parents gave their consent for their children to take part in this science case study and participated in a survey themselves, the parents became more aware of their child’s science experience at school and maybe gave their child more support in this subject?
e. Social Involvement or Peer Support

Like parental or home support social involvement is a factor, which is considered to be related to students' attitude, interest, motivation, and engagement (Fig. 2.1, Chapter 2). "Attitudes of peers towards science", is recognized by Simon (2000, p.105) as a factor of attitude. Social involvement is a source of 'situational interest' according to Palmer, (2007b). Social factors such as support from friends can influence student engagement (Pugh, 2004) and Harlen (2003a, p. 3) associates "peer culture" with motivation. It is apparent that social involvement or peer support may have been a variable impacting on attitudes to, and interest in, science, in this case study. The majority of students maintained their interest in science over the primary/secondary interface as these students were in classes where their peers were also study participants; peer support may have been a factor related to these students' attitudes and interest in science. One of the students, Bree who displayed a marked decrease in 'Science interest' was the only student in classes without any other study participants, in both year six and year seven. Another student Harry, whose 'Science interest' score decreased markedly, had social problems during science classes in both years six and seven. Social involvement appeared to be one of the factors replacing Alana's 'personal interest' in science, as 'spending time with friends' amongst other interests appeared to replace Alana's passion for science particularly relating to her agricultural interests (see 'Students with a passion for science' below). However it is important to be aware that this variable is only one of a number of factors that is associated with these students' attitudes to, and interest in, science.

5. Students with a Passion for Science and Listening to the Voice of Students

a. Students with a Passion for Science

In year six the students generally were very keen and enthusiastic towards science. However three students in the study in year six, displayed deep enthusiasm towards school science and science in society and it could be said that they were passionate towards the subject and had a 'personal interest' in science (Hidi, 1990). Although all three students maintained a high interest in the subject, only one of these three students maintained their
exceptional passion for school science over the primary/secondary interface. Both Alec and Alana along with the other students from 7K stated their strong dislike of the copious amounts of writing and their disappointment in the lack of practical activities in year seven. There appears to be a possible class effect that may have influenced Alec and Alana’s attitude to, and interest in, school science to some extent. However other factors such as Alana’s social life and her interest in drama may have impacted on her love of agricultural science and her desire to help her father on her farm. This fervour towards agriculture may have been a contributing factor to her exceptional passion for both school science and science in society in year six and maybe other interests were taking over from her ‘personal interest’ in science. Alec maintained a keen interest in science in society and continued to carry out experiments at home although he appeared to be a little disillusioned with his school science.

b. The Voice of the Students

Although there was no significant decrease in ‘Science interest’ for the 20 students in the case study generally, five students became significantly less interested in science over the primary/secondary interface and Alec and Alana appeared to lose their exceptional interest in science (for an overall picture of the student participants’ attitudes and interest relating to science, look at the Narratives for Students, Appendix I). If we are to address the issues of decreasing numbers of students choosing science subjects in senior secondary school and fewer students choosing science careers, it is essential that schools provide science lessons that are stimulating and engaging for the students. A study as part of the Nestlé Social Research Programme in 2004 also gave students a voice in science. The words for a press release for this study were “Girls like their science with a conscience” (as cited in Jenkins, 2006, p.59). This study supports other research where the voice of the students is loud and clear asking for stimulating practical science lessons that are relevant to the students (such as ethical and controversial issues), discussion is encouraged and where teachers engage with the students at their level (Palmer, 1999; Hanrahan, 2006; Murray & Reiss, 2005). However having made this statement about the common voice of students in science literature, the author of this thesis is not suggesting that voices of students are the same on all issues in science (Jenkins, 2006) rather there are international
similarities regarding the students' idea of engaging science practices such as those mentioned above and it is essential that educators pay attention to these ideas.

6. Response to Research Questions

The Following section looks at how the overall findings address the two research questions and assertions are made regarding these findings.

Research Question 1

How do children’s attitudes to, and interest in, science change across the primary/secondary interface?

Assertion 1
The participants in this case study, as a group, remained generally positive towards science, although there were several participant students whose interest did decline across the primary/secondary interface.

Research Question 2

What are the factors that affect the changes in attitude and interest towards science?

Assertion 2:
Possible Factors contributing to case study participant students’ positive attitudes to, and interest in, science, which were identified as a result of conducting this research study included: the students being given a voice by the researcher and having their ideas taken seriously; being part of a peer group of participants; developing a more positive self-esteem concerning science; motivation towards the subject; student reflection and discussion on the relevance of science; and the researcher providing a possible link between primary and secondary science.

Assertion 3:
Factors associated with a decline in students’ positive attitude towards, and interest in, science, over the primary/secondary interface included teaching quality, classroom pedagogy and environment, a perceived increase in science difficulty, lack of practical
work where students are encouraged to investigate independently, excessive note
taking, lack of independent research and limited use of ICT in science lessons.

Assertion 4:

Gender, ability and parental attitude did not appear to have a significant influence on
students’ attitudes towards science in this case study. Peer support may have
contributed to the fact that most students’ attitudes remained positive to science across
the primary/secondary interface. Lack of peer support or social involvement may have
influenced some students who appeared to become less interested in science in year
seven.

7. Summary and Implications for Educators

In contrast to the findings of many research studies in science education, (Baird,
Gunstone, Penna, Fensham, & White, 1990; Braund & Driver, 2005; Ferguson & Fraser,
Oliver, 1985) the majority of the 20 students in this study generally maintained their
positive attitude to, and interest in, school science, over the primary/secondary interface
with one student becoming considerably more interested and a number of students
maintaining or developing a ‘personal interest’ in science in year seven. There have been
few longitudinal in depth studies such as this study with a combination of both quantitative
and qualitative methods. These mixed methods of data collection allowed the researcher to
gain a glimpse of how these 20 students perceived their school science and science in
society. Although this case study involved a very small number of students and the
findings cannot be generalised, important issues have emerged that have implications for
science educators. For the students whose attitudes to science remained relatively stable
over the primary/secondary interface, aspects such as the enjoyment of practical science,
the new content and unusual equipment in secondary school appeared to help maintain
their positive attitudes towards the subject. It is possible that there was a Hawthorne effect
in this study as the participant students’ ‘Science interest’ score was significantly different
to those of the non participant students’, in year seven in 2005. Being part of a ‘peer group’
of participant students, giving students a voice in science to be able to express their views
and opinions, or their likes and dislikes of aspects of science, may have enhanced some
students’ self-esteem in science, or their motivation towards the subject. Thinking about
why science is presented in schools enabled them to think more seriously and deeply about the relevance of the subject. The continuation of the study from primary into secondary could have also provided a link and continuity in science over the primary/secondary interface.

Although the majority of students in this study remained positive to science over the primary/secondary interface, all students voiced their dislike of the excessive copying of notes in science and their enjoyment of practical activities in the subject. Five students' 'Science interest' significantly decreased over the primary/secondary interface. Factors that appeared to impact on some of these students' attitudes to science over the primary/secondary interface included the copious amounts of 'copying' in year seven, lack of student-centred practical work where students were given opportunities to make decisions, less opportunities for independent research with the use of computers, perceived increase in 'Difficult science' and differences in pedagogy, classroom environments in secondary school and for a small number of students lack of peer support or social involvement relating to science.

More boys in this study preferred science in secondary school to primary school and only girls (3 [of 11]) preferred science in primary school, but there were no significant differences between the 'Science interest' scores of boys and girls in year seven (both participant and non participant students). Links between ability and attitude towards science were not clearly apparent in this study, neither was there any obvious connection between students' attitude to science and parental attitudes.

There is a need for urgency to address the issues common to many Australian students (and many students internationally) of, lack of interest in school science, negative attitudes towards the subject, a decline in numbers of students choosing science subjects in senior secondary school, and fewer students choosing science related careers (see Chapter 2). A number of teaching practices and other factors have been identified in this study that 'spark' an interest in the subject and lead to student satisfaction in their science lessons. Students have also voiced their concern about practices that 'switch students off' in science and lead to boredom and frustration. If students' attitudes to school science are to remain positive it is essential that their school science experiences stimulate motivation and
engagement towards the science activities, and capture and maintain their interest over their schooling years.

The Following Chapter

Chapter 8 gives an overview of what this thesis has achieved. The findings of both the attitudinal study and the case study are compared and contrasted, and the limitations of the studies, the implications of the findings for educators and the significance of this research are discussed.
CHAPTER EIGHT
COMMONALITIES AND DIFFERENCES OF THE
ATTITUDINAL SURVEY AND CASE STUDY

Chapter Overview

This chapter firstly presents an overview of the research project, its limitations and significance. The commonalities and differences in the attitudinal study and case study are presented, implications for educators are discussed and a project that has been initiated by teachers in response to the research findings is introduced.

The chapter is divided into the following sections:
1. overview of the research project including limitations and its strengths;
2. commonalities of the case study and the attitudinal study;
3. differences in the findings of the case study and the attitudinal study;
4. conclusion to the attitudinal survey and case study, and implications for educators; and
5. where to from here

1. Overview of the Research Project Including Limitations and Strengths

This thesis has presented an overview of a study looking at the changes in students’ attitudes to, and interest in, science over the primary/secondary interface. The main component of this study was the case study, which involved a small sample of students ($N = 20$). It was helpful to draw on the findings of the attitudinal survey component ($N = 264$) to give an overall picture of students’ attitudes to science from years five to ten, in the school communities from where the case study participants were selected (Chapter 4). The attitudinal survey provided the opportunity to note any differences in student attitude in a number of different categories such as year group, ability and gender. However, this survey was limited for the following reasons: the survey was administered at one point in time and students were restricted to responding to certain questions using a Likert scale,
although there was an opportunity to provide a short response to ‘A good thing about science’ and ‘A bad thing about science’. In contrast, although limited by the small sample size, the case study provided rich data of students’ attitudes to, and interest in, science, over the primary/secondary interface and these mixed methods allowed cross-validation of data. Each student in the case study was given a voice and the students’ responses were supported by observational and anecdotal evidence (Chapter Five). This evidence was obtained from primary sources including observations of work samples and interactions between students, and between students and teachers. Secondary sources, such as teacher interviews and parental surveys were also conducted (Chapter 3). Both the quantitative data and these mixed qualitative data methods provided the researcher with a glimpse of how these 20 students perceived science in society and their school science, both in years six and seven and data was compared between the two years. By using the quantitative data and the multiple methods of the qualitative data together it was possible to cross-validate the data, and this strengthened any commonalities and differences emerging from the data between individual students and groups of students. The attitudinal surveys provided the researcher with a benchmark that revealed any differences between those students in the case study as a group and the other students in the same schools and classes where the study was conducted. Although generalisations would not be appropriate for a study with a small sample size, this study is significant as it is one of the few ‘in depth’ longitudinal studies with multiple methods of data collection looking at this area of student attitudes towards science. The importance of studies that look at clarifying attitudinal and motivational research and investigating “how the theoretical orientations and constructs relate to one another” for example “how attitudes influence motivation and how motivation influences science learning and ultimately behaviour” is emphasized by Koballa & Glynn (2007, pp. 94,95). Although this study has not looked primarily at science learning it has sought to look at the relationship between, and the factors that influence the constructs “attitude, interest, motivation, and engagement” and ‘student learning’ is a factor associated with these constructs (Figure, 2.1 & 2.2, Chapter 2). When analysing the multiple methods of data a number of common factors were revealed that encouraged motivation towards, and engagement in science activities and assisted students in maintaining a positive attitude to, and interest in, science
throughout their schooling and in some cases stimulating a ‘personal interest’ in the subject (Hidi, 1990). Factors that led to a decline in interest to, and a positive attitude in, science were also revealed. Sustaining a positive attitude towards, and an interest in, science, may influence students in their choice of the subject in senior high school (Lindahl, 2003) and eventually in the decision to undertake a career in science (Simon, 2000). Retaining a positive attitude towards, and interest in, school science and science in society, is also an important factor in helping students stay focussed towards, and engaged in the subject (Simpson, Koballa, Oliver & Crawley, 1995) in order to achieve scientific literacy before graduating from school. After all increasing scientific literacy in the population is the key goal of science curricula generally (Feasey, 2004; Gerber, 2001) and could lead to students appreciating the world around them. “Ideally students of science should learn to use their knowledge and skills to become caretakers of the world, preserving it and enhancing it for generations to come” (Koballa & Glynn, 2007, pp. 95,96)

2. Commonalities of the Case Study and the Attitudinal Study

The findings of both studies revealed a number of commonalities, although differences were also apparent. There were no gender or ability differences in attitude to, and interest in, science, evident in either the case study or the attitudinal survey, over the primary/secondary interface although there were differences in preference of aspects of science between boys and girls, and students of high and mixed abilities. It needs to be noted that although there were no ability differences over the primary/secondary interface in the attitudinal survey, the lesser ability female students as they progressed through secondary school were most susceptible to losing interest in science. If further science attitudinal research was undertaken, that was designed to look at differences between gender, and / or students of different ability levels, more differences may emerge. Factors that did appear to influence some students’ attitudes to, and interest in, science, in both the case study and the attitudinal survey, were pedagogical practices and classroom environments. Students’ love of classroom environments with practical science, particularly student-centred investigations (where students were encouraged to independently hypothesize, explore and investigate) together with students’ dislike of ‘chalk and
Chapter Eight

talk’ style of lessons where copious amounts of copying (of notes) took place, were frequently noticed features common to both studies. Comments about pedagogy were present in both studies, most frequently in secondary school and particularly regarding aspects of science that ‘turn students off’ science. These comments included: being rushed through content, humiliation by the teacher, unclear explanations, teacher demonstrations in place of student-centred practical lessons and being told results of experiments before undertaking them. Pedagogy is clearly a factor that impacts on students’ attitudes to, interest in, motivation towards, and engagement in science and one that needs to be addressed.

3. Differences in the Findings of the Case Study and the Attitudinal Study

There was a significant decline in students’ positive attitude towards science over the primary/secondary interface in the attitudinal survey; this trend was also apparent when the attitudinal survey was repeated in 2005 with non-participant students. In contrast the students in the case study generally maintained their positive attitude towards science over the primary/secondary interface as a group and one student had a marked increase in his ‘Science interest’ although five students (25%) revealed a decline in attitude towards science in year seven. The majority of the students in the case study saw the relevance of school science not only for careers but also for life skills. Anecdotal evidence such as the enthusiasm of the students in the case study towards the research, particularly knowing their ideas were to be published in documents, and various comments from teachers about the students’ enthusiasm towards the study, suggested the students appreciated being taken seriously and being given a voice to express their opinions about aspects of science. The students also seemed to enjoy being part of a peer group of study participants and enthused each other in science. A familiar face in year seven provided a link between primary and secondary school science and this could have assisted in the Case study students maintaining their positive attitudes towards science. Other relevant suggestions that the case study participants put forward such as features they would like to see included in their school science were: science that addressed issues that are relevant to the lives of the students, such as issues of water use; class discussions and debates about aspects, such as environmental issues; use of the school grounds for science
lessons; more science excursions; and an increase in the use of information communication technology (ICT) including student use of computers to record information about science (for example: the use of power point presentations), student use of video cameras or digital cameras, viewing scientific videos, the use of interactive CD-ROMs and taking part in internet based research.

4. Conclusion to the Attitudinal Survey and Case Study and Implications for Science Educators

If students' interest can be maintained across the primary/secondary interface, as has occurred in this case study, with the majority of the 20 participant students, even if it is a result of the Hawthorne effect of this study (Chapter 7), then educators should be trialling practices which have been identified in this study and are supported by other science education literature, that increase the chances of interest being stimulated and positive attitudes being maintained. Science is becoming increasingly important in this highly technological world and there is a decline in numbers of students choosing science subjects in senior secondary school (Goodrum, Hackling & Rennie, 2001) and a shortage of scientists which is predicted to increase substantially (Metherell, 2006); surely this is a crisis. It is essential that students are encouraged to embrace science and technology and become familiar and comfortable with science throughout their schooling. If secondary science in Australia is essentially the 'chalk and talk' style of teaching, with recipe like practical lessons (Goodrum, Hackling & Rennie, 2001) which according to this research study appear to 'bore' students, and science is frequently overlooked in primary school as a result of a crowded primary curriculum (Goodrum, Hackling & Rennie, 2001), how is a positive attitude to science to be maintained? By looking at the results of this research project where students were given a voice in science, were taken seriously, and where the researcher gained a glimpse of how these students perceived their school science, it is possible to identify many of the factors that lead to motivation and engagement in science activities, stimulated interest in, and a positive attitudes towards, science. It is also possible to see what 'turned some students off' science and what the majority of these students disliked about their science lessons. The use of multi-modal representations of science would be a significant area of research, including integration of science with arts; such as: role-plays, group posters and the
use of ICT in science classrooms to enhance student interest in science. Incorporating the ICT ideas suggested by the students in this study together with the use of interactive whiteboards, data loggers, robotics, digital microscopes and student podcasting with science themes would all be practices that would help bring school science into the 21st Century.

There is an urgent call for educators to ‘re-think’ the way science is presented in schools (Holbrook, 2007; Tytler, 2007a). There has been little change in the way science has been presented over the decades in secondary schools with the traditional teacher-centred lessons where students have little input into the theory lessons or direction of the practical lessons (Goodrum et al, 2001). This style of science, which is often seen as catering for the intellectually elite (Tytler, 2007a), is clearly not capturing the interest of students in the 21st Century. It is evident that pedagogy is one of the most significant factors that impact on students’ attitudes to, and interest in, science, and this area needs to be addressed most urgently. The results of this study combined with information from other literature incorporated in this thesis could provide educators with ideas for teaching practices and classroom environments that could stimulate interest in the subject, give students a chance to explore, independently investigate, and discuss, real life issues that are relevant to those students and may assist students in enhancing their self-esteem in science and lead to the development of positive attitudes towards the subject and a ‘personal interest’ in science.

Where to from Here

The case study is continuing using similar data collection methods each year and will go through to year ten with the students who agreed to continue to participate. It will be interesting to note if there are any further changes in attitude towards science with the case study participants throughout secondary school and to ascertain if their attitudes to science impact on their subject choices in senior school.

It seemed relevant here to include a chapter discussing an initiative in response to the findings of the attitudinal surveys in this thesis. The teachers from the participant schools initiated a project to enhance innovative teaching in science, to endeavour to
maintain students’ positive attitudes to science across the primary/secondary interface after being presented with the results of the attitudinal surveys. The following chapter outlines the project and analyses a bridging unit of work, which was implemented as part of this project in the schools where the attitudinal study and case studies were conducted. Chapter nine compares the attitudes to, and interest in, science of the year seven students who participated in the attitudinal survey in 2004 but had not been involved in a bridging unit, with year seven students after they had completed the bridging unit associated with this project in 2007. This chapter reinforces the importance of pedagogy that stimulates interest in science and enhances positive attitudes towards the subject. Addressing the problems associated with the presentation of science in the classroom and impacting on students’ attitudes to science is by no means a simple task. However it is essential that there is move to bring school science into the 21st Century and convince teachers to adopt innovative strategies in their presentation of science. Difficulties associated with a project of this nature are highlighted throughout Chapter nine. As the project is continuing only a component of this project is discussed in the following chapter but it is important to highlight areas of urgency that need to be addressed (Chapter 9). In the final section (Part 3) of the following chapter there is an outline of teaching practices that enhance innovative teaching in science. These practices have been revealed as a result of analysing the data from all three studies: the attitudinal survey; the case study; and the bridging project, and is supported by other research studies into attitudes to science.
CHAPTER NINE

A PROJECT TO ENCOURAGE THE SMOOTH TRANSITION OF STUDENTS FROM PRIMARY INTO SECONDARY SCIENCE

Overview

As this project was initiated by the teachers from the participant schools involved in the attitudinal survey to address the decline in the positive attitudes of students towards science over the primary/secondary interface it seemed relevant to include an outline and analysis of components of this project as part of this thesis. The project in its entirety is not discussed in this chapter, as it is still continuing. As the project is not essentially part of this overall study but evolved in response to the findings of the ‘attitudinal survey’, the design of this project is not included in the Research Design and Methods (Chapter 3). The design is outlined below. The chapter is divided into the following sections:

1. part one discusses the background and a general outline of the project;
2. part two analyses a bridging unit of work, which was developed as part of this project; and
3. part three discusses the constructs, attitudes, interest, motivation and engagement; relating to the studies analysed in this thesis.

Background to the Project

In the review of the 2006 “Boosting Science Learning – what will it take?” Australian Council for Educational Research (ACER) conference, Tytler (2007a) discussed the failure over the past two decades to reform science. However he described a current “genuine mood for change” amongst science educators at all levels and science policy makers (p. 3). He believed the underlying stimulus of this change in attitude has been the “flight from science serving as a wake-up call” (p. 3). This chapter illustrates an example of this desire for change in science education where the research study outlined in this thesis inspired teachers to take action. The chapter also highlights the difficulties associated with change. Unfortunately in reality implementing change is a complex matter and not something that can happen overnight. Best intentions and innovative ideas do not always lead to the outcomes we are striving for. However this project has sewn the seed of desire to change with a number of teachers from the participant schools.
Chapter Nine

What Initiated this Project?

The findings of the attitudinal survey examined in this thesis were presented to both primary and secondary teachers of the schools involved in the study; the teachers (particularly the secondary teachers) were alarmed by the results of the study that revealed students’ decline in positive attitude towards science as they moved from primary school into secondary school. In response, a group of teachers from the secondary school and its six feeder primary schools initiated a project to enhance innovative teaching in science, to endeavour to maintain students’ positive attitudes towards science across the primary/secondary interface. The schools were successful in obtaining a grant, funded by the Department of Education, Science and Training (DEST). Teacher representatives from the secondary school and its feeder primary schools have been involved in the organisation of the project. Australia's Commonwealth Scientific and Industrial Research Organisation (CSIRO) and local scientists have also been involved in the project. It needs to be stated once again that this project and its design was an initiative of the teachers not the researcher (and Author of this thesis). However the researcher was asked to assist and was included as part of the project team.

The duration of the project is officially over a period of 18 months, from July 2006 to December 2007. However there will be aspects that will be continued into 2008 and beyond and it is anticipated that many of these initiatives will be incorporated into the schools’ science programmes.

The initial overall aim of this project, which was outlined in the project proposal application, was to create a smooth transition from primary school into secondary school. This was to be achieved by the teachers from the partner schools working together to develop and share innovative and successful teaching practices and learning strategies. There was to be a focus on problem-based learning to encourage a student-centred learning approach where students were encouraged to construct ideas from their own exploration, research and investigation. It was hoped that the schools would work together to provide a unified approach to curriculum outcomes and this would be assisted by the purchasing of resources to share between the feeder primary schools.
Chapter Nine

Initiatives and activities undertaken and as part of this project prior to July 2007 when the bridging unit was completed (the bridging unit will be discussed in detail below in part 2) are presented in a timeline in Figure 9.1

Further initiatives were planned to take place later in 2007 after the initial bridging unit was completed and these are outlined in Figure 9.2.

An outline and analysis of the bridging unit of work that was set up as part of this project has been included in this chapter where a comparison has been made between the science interest scores from the ‘attitudinal survey’ of students in year 7 in 2004, and the scores of the students who completed the bridging unit in June 2007 (for the comprehensive results of scores of the attitudinal survey [Pell & Jarvis, 2001] conducted in 2004 and 2005 refer to Chapter 4). Following on from this the implications for educators arising from this bridging unit are discussed. Further attitudinal surveys and other research data will be conducted as part of this project at a later date (Figure 9.2) but will not be included in this thesis.
Chapter Nine

Teachers from each participant school meet to discuss project and resources.

Forum and professional development to discuss research into students' attitudes towards science and outline bridging unit.

Professional development workshop for secondary teachers with visiting teacher to look at enquiry-based learning and to develop units of work using this approach.

The production of the scientists' DVD where people in a variety of science-based careers were interviewed. DVD to be viewed by year six students in 2006.

Teacher Associate met with primary teachers in individual schools to explain bridging unit and provide resources for the unit to be implemented. There was also assistance provided with some bridging unit lessons.

Attendance of year six students at science workshops in participant secondary school.

Slide presentation for year seven secondary students in 2007 to overview the primary school component of the bridging unit (from year six 2006) and one (only) 2007 bridging lesson implemented.

A visit by year seven secondary students to a science research centre to see local scientists at work.

Commencement of project.

Teacher Associate (Author of this thesis) and project Co-ordinator meet to discuss project initiatives and organise a professional development session and forum for project team.

Project meeting to discuss draft of bridging unit.

Student-centred practical science activities in the feeder primary schools conducted by pre-service primary teachers from Southern Cross University (where the students were encouraged to independently explore or investigate).

Project meeting to finalise bridging project and discuss implementation.

Purchase of equipment for science resource kits for feeder primary schools to ensure students undertake the same science content areas before entering secondary school to avoid repetition of work by choosing topics to complement the year seven secondary science experience.

Purchase of interactive white boards for use in secondary science lessons to: enhance science activities by the use of visual displays to illustrate conceptual ideas with the use of animations, photographic images or interactive diagrams; allow students to interact by sharing work, where individual or group work can be displayed and adapted to encourage collaborative work and promote discussion; and record results which could be converted to text and distributed to the students to reduce the amount of copying notes from the board (see Chapter 6, 3d).

Project meeting to discuss bridging unit at secondary school. Slide presentation developed for year seven students to reflect on their primary bridging unit, lessons to be presented in first term.

Project meeting to discuss project and welcome new Co-ordinator of project (Secondary Science Co-ordinator).

Attitudinal Survey administered to year seven students after completion of the bridging unit, later in term two, 2007.

Figure 9.1

Timeline of Initiatives and Activities Undertaken as Part of the Project Outlined in this Chapter, Prior to the Administration of the Pell and Jarvis (2001) Attitudinal Survey in June 2007

<table>
<thead>
<tr>
<th>Date</th>
<th>Event</th>
</tr>
</thead>
<tbody>
<tr>
<td>Early July 2006</td>
<td>Commencement of project.</td>
</tr>
<tr>
<td>July 1st 2006</td>
<td>Teacher Associate (Author of this thesis) and project Co-ordinator meet to discuss project initiatives and organise a professional development session and forum for project team.</td>
</tr>
<tr>
<td>August 23rd 2006</td>
<td>Project meeting to discuss draft of bridging unit.</td>
</tr>
<tr>
<td>September 4th 2006</td>
<td>Project meeting to discuss draft of bridging unit.</td>
</tr>
<tr>
<td>September 19th 2006</td>
<td>Student-centred practical science activities in the feeder primary schools conducted by pre-service primary teachers from Southern Cross University (where the students were encouraged to independently explore or investigate).</td>
</tr>
<tr>
<td>September 21st 2006</td>
<td>Project meeting to finalise bridging project and discuss implementation.</td>
</tr>
<tr>
<td>Sept/October 2006</td>
<td>Purchase of equipment for science resource kits for feeder primary schools to ensure students undertake the same science content areas before entering secondary school to avoid repetition of work by choosing topics to complement the year seven secondary science experience.</td>
</tr>
<tr>
<td>October 2006</td>
<td>Purchase of interactive white boards for use in secondary science lessons to: enhance science activities by the use of visual displays to illustrate conceptual ideas with the use of animations, photographic images or interactive diagrams; allow students to interact by sharing work, where individual or group work can be displayed and adapted to encourage collaborative work and promote discussion; and record results which could be converted to text and distributed to the students to reduce the amount of copying notes from the board (see Chapter 6, 3d).</td>
</tr>
<tr>
<td>November 2006</td>
<td>Project meeting to discuss bridging unit at secondary school. Slide presentation developed for year seven students to reflect on their primary bridging unit, lessons to be presented in first term.</td>
</tr>
<tr>
<td>March 5th 2007</td>
<td>Project meeting to discuss project and welcome new Co-ordinator of project (Secondary Science Co-ordinator).</td>
</tr>
<tr>
<td>Late May/June 2007</td>
<td>Attitudinal Survey administered to year seven students after completion of the bridging unit, later in term two, 2007.</td>
</tr>
</tbody>
</table>

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A bridging unit of work with a different theme to be implemented for year six students in the final term of 2007 (covering a physics theme and this will include a visit to the secondary school to take part in activities relating to air pressure). It will continue early in 2008 when the students are in year seven.

Professional development sessions to be undertaken by primary teachers to learn about the strategies behind the ‘Primary Connections’ units of work (Australian Academy of Science, 2006) and constructivist teaching practices generally.

Science workshops to be implemented by CSIRO where years six and seven students interact in groups in 2nd term (August) 2007 (this is to be repeated in third term, 2008).

Pre-surveys to be undertaken in 2007 (year six) prior to the bridging unit and post-surveys to be undertaken in 2008 (year seven) using the Pell and Jarvis (2001) attitudinal survey.

Figure 9.2

*Timeline of Initiatives and Activities to be Undertaken as Part of the Project Outlined in this Chapter, After the Administration of the Jarvis and Pell (2001) Attitudinal Survey in June 2007*
Part Two

Analysis of the Bridging Unit for students in Year 6, 2006 and Year 7, 2007

Part two is divided into the following sub-sections:

a. students and schools participating in this project;

b. the bridging unit design;

c. outline, administration and method of analysis of the attitudinal survey in 2007 to obtain cross-sectional data;

d. problems associated with the implementation of the bridging unit and the method of analysis of the attitudinal surveys;

e. comparison of attitudinal survey results of 2004/2005 year seven cohorts with the 2007 cohort after completion of the bridging unit;

f. a discussion relating to the results of the 2007 Attitudinal Survey and comparisons of these results with those of the attitudinal survey in 2004.

a. Students and Schools Participating in the Project

In 2006 there were a total of 211 students who participated in the project from the six primary feeder schools of the secondary school (school ‘C’, Table 3.2, Chapter 3) (Table 9.1). All participant schools in the ‘attitudinal survey’ and ‘case study’ (Table 3.2, Chapter 3) plus an additional three schools were involved in the project (Table 9.1). There was one Catholic primary school (school G, Table 9.1) and six state schools (five primary: one secondary). Although the majority of students from the state feeder schools went on to the secondary school (School C) only a small number of students from the Catholic school (School G) went on to the secondary (School C) school in 2007. However the Catholic school was part of the school community and the teachers were keen to take part in this local project. There was a combination of three larger primary schools ($N=98, 48 \& 48$, Table 9.1) and three rural schools with small numbers of students in year six involved in this project ($N= 4, 5 \& 8$; Table 9.1). In year seven, 2007, there was a total of 163 students who attended the secondary school (School C) and the majority of these students came from the feeder primary schools in the project.
Table 9.1

Sample Characteristics for the Schools Involved in the Attitudinal Survey in 2007 (Number of Students by Year Group)

<table>
<thead>
<tr>
<th>School</th>
<th>School Year</th>
<th>Calendar Year</th>
<th>Number of Students in Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>*A (Primary State School)</td>
<td>6</td>
<td>2006</td>
<td>98</td>
</tr>
<tr>
<td>*B (Primary State School)</td>
<td>6</td>
<td>2006</td>
<td>48</td>
</tr>
<tr>
<td>*D (Primary State School)</td>
<td>6</td>
<td>2006</td>
<td>8</td>
</tr>
<tr>
<td>E (Primary State School)</td>
<td>6</td>
<td>2006</td>
<td>5</td>
</tr>
<tr>
<td>F (Primary State School)</td>
<td>6</td>
<td>2006</td>
<td>4</td>
</tr>
<tr>
<td>G (Primary Catholic School)</td>
<td>6</td>
<td>2006</td>
<td>48</td>
</tr>
<tr>
<td>Total Students in Primary</td>
<td>6</td>
<td>2006</td>
<td>211</td>
</tr>
<tr>
<td>*C (Secondary State School)</td>
<td>7</td>
<td>2007</td>
<td>163</td>
</tr>
</tbody>
</table>

Note. Schools: *A, *B, *C = *Participant Schools in 2004 Attitudinal Survey School: *D = *Participant school in Case Study 2004/2005 Schools: E, F & G = not in 2004/2005 Attitudinal Survey or Case Study *The labelling of schools was developed for the attitudinal survey (outlined in chapter 4). As there were only three participant schools in the original attitudinal survey the secondary school was labelled School C.
b. The Bridging Unit Design

Research studies have shown that some bridging units developed in science in the final term of primary school and the first term of secondary school have resulted in students maintaining positive attitudes towards science over the primary/secondary divide (Braund & Hames, 2005) although there have been problems associated with bridging programmes (Galton et al., 2003a, 2003b, as cited in Braund & Hames, 2005).

This project was initiated to address the issue of students developing less positive attitudes to science as they move from primary school into secondary school (Table 4.4, Chapter 4). Representative teachers from the secondary school and its six feeder schools together with the Teacher Associate (researcher) designed a unit of work as part of this project which was undertaken by all year six students in the six primary schools in 2006 (Table 9.1) and was continued in year seven, 2007 when the students started secondary school. It was hoped that this bridging unit of work would provide the students with continuity between primary and secondary school. Part of this unit involved visits to the secondary school by the year six students with their primary school teachers in November 2006 (Figure 9.1) to work in the science laboratories where they were to undertake their science in year seven. Taking part in these sessions at the secondary school in the science labs may have provided familiarity and have eased the border crossing into the science world of secondary school for the students involved (Aikenhead, 1996). The primary school component of the unit consisted of six lessons in the final term of year six, 2006, plus the secondary laboratory workshop. The secondary school component of this unit was to consist of a review lesson of the bridging unit from year six, two science practical lessons, and a visit to observe scientists at work in a science research institute in year seven, 2007, but due to pragmatic difficulties only the review lesson, one practical lesson and the visit to the institute were completed. Ideally this component was to be conducted early in 2007 to allow continuity of year six with year seven. However it was not carried out until later in term two, (May/June, 2007) (Figure 9.1). The secondary lessons were designed to follow the NSW Board of Studies science syllabus requirements for stage three and four and complement the general programme of work designed by the secondary school teachers.
Chapter Nine

All representative teachers in this project took part in a professional development day in August 2007, prior to designing this unit (Figure 9.1), where factors identified in research studies that lead to positive attitudes towards science, and those that lead to negative attitudes towards the subject were discussed. These teachers were introduced to general constructivist principles and the 5E’s model outlined in the *Primary Connections* resource documents and DVD, based on the 5Es instructional model (Bybee, 1997 cited in Australian Academy of Science, 2006).

The lessons conducted in year six were underpinned by the 5Es model, to promote student-centred learning, enhance science skills, encourage the students to build on their existing knowledge of the role of scientists and gain a deep understanding of the varied and interesting nature of science careers. The 5Es model involves five stages these are:

i. **engage**: where students are engaged with an activity or question and the opportunity is provided for the students to express what they know about the topic or concept;

ii. **explore**: where students through ‘hands on’ learning explore in order to build on their understanding of a concept and test their own theories;

iii. **explain**: where students with the help of the teacher develop explanations for the phenomena they have experienced;

iv. **elaborate**: where the students are encouraged to develop a deeper understanding of the concept or skill through carrying out investigations and discussing and comparing ideas; and

v. **evaluate**: where the students’ reflect on their new learning and understanding and revisit their original ideas about the concept to see how their understanding has been challenged, changed and/or supported (Australian Academy of Science, 2006).

The unit ‘the crime busters’ was designed to engage the students by using the novelty theme of forensics where students were assigned to assist the police in solving a fictional local bank robbery. Taking part in novelty activities has been found to stimulate situational interest in science and situational interest has been associated with positive attitudes towards the subject (Palmer, 2004). The lessons based on the 5E’s included the following:
• an elicitation activity looking at students' perception of scientists;
• an exploration activity identifying mystery powders;
• an explanation lesson which involved the viewing of 'the scientists' DVD produced for the project to illustrate the diversity of science based careers and further discussion about scientists;
• an elaborate lesson where students designed an investigation (involving fair testing) to find the best method to identify a mystery footprint;
• an optional elaborate lesson where students constructed identikits of suspects using a computer programme accessed by the internet;
• a further elaborate lesson in a science laboratory conducted at the high school where the students extracted DNA and made use of the interactive whiteboard to develop their knowledge and understanding; and
• an evaluation lesson where the students revisited their initial ideas about scientists and reflected on how their ideas had been challenged, changed or supported.

Resource kits were developed to make the unit easy for implementation in the primary schools: they included the outline of the unit of work for teachers, student work sheets, the mystery powder kit, 'the scientists' DVD, suspects shoes and a digital photo of a shoe print from the crime scene.

Prior to designing the unit of work the secondary representative teachers undertook professional development to look at enquiry-based learning, a method where students are encouraged to question and seek answers to their questions by investigating or researching. This involved developing units of work using this student-centred approach for year seven in 2007. The secondary component of the bridging unit was also designed using this enquiry-based approach. In year seven the students participated in a review lesson where they reflected on their primary 'crime busters' lessons with the use of a power point presentation where they viewed images of themselves taking part in the activities in 2006 and an outline of the unit of work that they had previously completed. The additional lessons involved a chromatography activity to analyse ink from a ransom note issued by the bank robber, a visit to a research laboratory to observe scientists at work and a soil analysis lesson where soil from the fictional crime scene was to be analysed and the 'bank robber' identified. The attitudinal survey was administered after the students had completed the bridging unit in June 2007.
Making science relevant to the students’ own world is one of the key factors leading to student engagement and positive attitudes towards science (Tytler, 2007a). Written comments by the students taking part in the attitudinal survey in 2004 in response to the question what is “a bad thing about science” included comments suggesting students could not see the relevance of science such as, science is “interesting in a way but not relevant to us” (Chapter 5). It was hoped that if students became familiar with the importance of science within society, were introduced to the variety of careers involving science, took part in discussions about scientists, and had the opportunity to visit scientists at work, that they may become more aware of the relevance and importance of science. Discussing and becoming aware of the relevance of science was thought to be one of the factors associated with the case study participant students’ maintaining their positive attitudes towards science over the primary/secondary interface (Chapter 7).

Taking part in student-centred science where students are encouraged to carry out open-ended investigations while working collaboratively in groups to explore and solve problems in science are practices that lead to high levels of student satisfaction (Harlen & Wake, 1999). This bridging programme involved lessons designed using the 5E’s in primary school and the enquiry-based approach in secondary school where students were encouraged to carry out student-centred exploration and investigating activities. The lessons were planned with the aim of stimulating interest, leading to motivation, engagement and hopefully resulting in students maintaining positive attitudes towards the subject over the primary/secondary divide.
c. Outline, Administration and Method of Analysis of the Attitudinal Survey in 2007 to Obtain Cross-sectional Data

Outline of Survey

An outline of the attitudinal survey as written in Chapter 3, has also been included in this Chapter. Pell and Jarvis (2001) developed the validated attitudinal questionnaire used in this attitudinal survey (Appendix E). This questionnaire contained 43 items in 3 main scales that consisted of: ‘Being in school’; ‘Science experiments’; and ‘What I really think of science’ (Table 3.1, Chapter 3). Further analysis revealed five sub-scales. These were: ‘Liking school’; ‘Independent investigator’; ‘Science enthusiast’; ‘Social context’; and ‘Difficult science’ (Table 3.1, Chapter 3). Three of these subscales were combined to create a composite sub-scale ‘Science interest’ (Table 3.1, Chapter 3). A copy of this attitudinal questionnaire can be found in Appendix E.

There were minor changes from the Pell and Jarvis (2001) questionnaire. These were: “doing sums”, which was changed to “doing maths”; the word ‘geometry’, which was added to “working with shapes”; “school science clubs are a good idea” was changed to “school science clubs would be a good idea”; and the cartoon runner on each page was deleted. All other item wording was kept the same.

This instrument had suitable reliability statistics for its various derived sub-scales and similar or better scale reliabilities were found when the questionnaire was used in this attitudinal study (see Table 3.1, Chapter 3).

Administration

This survey was administered by the year seven-classroom teachers midyear, 2007 (at the end of term 2, see Figure 9.1). The questionnaire was designed to be self-explanatory. However, the students were shown the sample question by their teachers and asked to ensure that all sections of the survey were completed.
Method of Analysis

The results were analysed using SPSS. In order to ascertain what change, if any, occurred, the mean scores on the various sub-scales of the students in 2004 were compared with the students who had completed the bridging unit of work in 2007 (see Table 9.2). As stated in Chapter 3, all items were worded to avoid negative phraseology, which Pell and Jarvis (2001) argued would make these items more accessible to young children, also all items were recoded (5=1, 4=2 etc.) in order that high interest could be aligned with high scores, and the low interest aligned with low scores. Scores for the derived sub-scales of ‘Independent investigator’ (9 items; max 27, [Independent investigator consisted of 9 items from ‘Science experiments’, Table 9.3, item 7 was not included]), ‘Science enthusiast’ (8 items; max 24, Table 9.4), ‘Social context’ (8 items; max 24, Table 9.4) and ‘Difficult science’ (5 items; max 15, Table 9.5),

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1 The students who participated in the attitudinal survey in 2004 were required by the Human Research Ethics Committee at Southern Cross University to submit written parental permission forms to take part in the research. Therefore only the students whose parents completed the permission forms were able to take part in the survey and the parents who were willing to complete these forms may have held a more positive attitude towards science; hence it is possible that these parents influenced their children’s attitudes. As all students were involved in the project initiated by the teachers from the participant schools in 2007 written permission to undertake the survey was not required, therefore the parents’ attitudes towards science was clearly not a factor. However anecdotal evidence of the year seven students in 2004 such as verbal responses suggested that many of the students were disillusioned with their secondary science and the common written responses in 2004 and 2007 (see Chapter 9 section 2e) suggested that there was little difference between the samples. It should be noted that there was a marked decline in positive attitude of the students in year seven secondary school compared with the attitudes of those students in year six primary school in 2004, and only the students whose parents returned the forms in 2004 from the primary (as well as the secondary schools) were able to take part in the study (Chapter 4, Table 4.8).
Table 9.2

Sub-scale Scores between Year Seven Students in 2004 (from Attitudinal Surveys before completing Bridging Unit) and Year Seven Students in 2007 (after completing the Bridging Unit)

<table>
<thead>
<tr>
<th>Derived sub-scale</th>
<th>Year 7 Students 2004</th>
<th>Year 7 Students After Completing Bridging Unit in 2007</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Max Score</td>
<td>Mean</td>
</tr>
<tr>
<td>2. Independent investigator (collapsed -3pts 9 items)</td>
<td>27</td>
<td>20.9</td>
</tr>
<tr>
<td>3. Science enthusiast (8 items -3pts)</td>
<td>24</td>
<td>12.6</td>
</tr>
<tr>
<td>4. Social context (8 items -3pts)</td>
<td>24</td>
<td>18.6</td>
</tr>
<tr>
<td>5. Difficult science (5 items-3pts)</td>
<td>15</td>
<td>10.2</td>
</tr>
<tr>
<td>6. Science interest (25 items a composite score of 2+3+4 -3pts)</td>
<td>75</td>
<td>52.2</td>
</tr>
</tbody>
</table>

Notes

- No significant difference at the 0.05 level was found between year seven students in 2004 and year seven students’ in 2007 (after completing bridging unit), using a two tailed t-test.
- 3pts = 3 point scale.
Table 9.3

Item Responses for ‘Science Experiments’ (the Sub-scale ‘Independent Investigator’ consisted of the items from ‘Science Experiments with item 7 deleted) 2004-2007

<table>
<thead>
<tr>
<th>Item Description</th>
<th>Year Seven 2004 Students</th>
<th>Year Seven 2007 Students After Completing Bridging Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean N SD</td>
<td>Mean N SD</td>
</tr>
<tr>
<td>How do you feel about</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Watching the teacher do an experiment</td>
<td>3.2 73 1.2</td>
<td>2.9 143 1.2</td>
</tr>
<tr>
<td>2. Working out what to do yourself</td>
<td>3.1 73 1.1</td>
<td>3.2 143 1.3</td>
</tr>
<tr>
<td>3. Teacher telling you what to do</td>
<td>3.1 73 1.1</td>
<td>2.9 143 1.2</td>
</tr>
<tr>
<td>4. Choosing your own equipment</td>
<td>4.1 73 1.0</td>
<td>3.9 143 1.1</td>
</tr>
<tr>
<td>5. Finding out what happens yourself</td>
<td>4.3 73 0.9</td>
<td>4.1 143 1.1</td>
</tr>
<tr>
<td>6. Working by yourself</td>
<td>3.1 73 1.3</td>
<td>3.0 143 1.6</td>
</tr>
<tr>
<td>7. Working with friends</td>
<td>4.6 73 0.9</td>
<td>4.6 143 0.9</td>
</tr>
<tr>
<td>8. Finding out why the experiment works</td>
<td>3.6 73 1.1</td>
<td>3.5 143 1.2</td>
</tr>
<tr>
<td>9. Telling teacher what you have done</td>
<td>3.1 73 1.1</td>
<td>3.3 143 1.2</td>
</tr>
<tr>
<td>10. Telling friends what you have done</td>
<td>3.5 73 1.1</td>
<td>3.5 143 1.2</td>
</tr>
</tbody>
</table>

Note. For each item differences were tested using two tailed t-tests for all items p>.05
Table 9.4

*Item Responses for Sub-scales 'Science Enthusiasm' and 'Social Context' 2004 - 2007*

<table>
<thead>
<tr>
<th>Item (ordered by sub-scale)</th>
<th>Year Seven 2004</th>
<th>Year Seven 2007 (After Completing Bridging Unit)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>N</td>
</tr>
<tr>
<td><strong>Science Enthusiast (3 point scale)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. I should like to be a scientist</td>
<td>1.5</td>
<td>72</td>
</tr>
<tr>
<td>5. I like science more than any other school work</td>
<td>1.3</td>
<td>72</td>
</tr>
<tr>
<td>6. I often do science experiments at home</td>
<td>1.3</td>
<td>72</td>
</tr>
<tr>
<td>13. I like to watch science programs on TV</td>
<td>1.7</td>
<td>73</td>
</tr>
<tr>
<td>14. School science clubs are a good idea</td>
<td>1.8</td>
<td>73</td>
</tr>
<tr>
<td>16. I am always reading science stories</td>
<td>1.4</td>
<td>73</td>
</tr>
<tr>
<td>17. I should like to be given a science kit as a present</td>
<td>1.6</td>
<td>73</td>
</tr>
<tr>
<td>20. One day, I should like to go to the moon</td>
<td>2.0</td>
<td>73</td>
</tr>
<tr>
<td><strong>Social Context (3 point scale)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Science is good for everybody</td>
<td>2.1</td>
<td>72</td>
</tr>
<tr>
<td>3. Lots more money should be spent on science</td>
<td>2.0</td>
<td>72</td>
</tr>
<tr>
<td>8. It is easy to find out new things in science lessons</td>
<td>2.3</td>
<td>72</td>
</tr>
<tr>
<td>9. Science has made us better and safer medicines</td>
<td>2.8</td>
<td>72</td>
</tr>
<tr>
<td>10. TV, telephones and radio have all required science</td>
<td>2.7</td>
<td>72</td>
</tr>
<tr>
<td>11. Our food is safer thanks to science</td>
<td>2.4</td>
<td>72</td>
</tr>
<tr>
<td>15. Science makes me think</td>
<td>2.3</td>
<td>73</td>
</tr>
<tr>
<td>19. Science can make chemicals we need from rocks</td>
<td>2.2</td>
<td>72</td>
</tr>
</tbody>
</table>

*Note.* For each item differences were tested using two tailed t-tests. All items: p>.05.
### Table 9.5

*Item responses for 'Difficult Science' 2004 - 2007*

<table>
<thead>
<tr>
<th>Item (ordered by sub-scale)</th>
<th>Year Seven 2004</th>
<th>Year Seven 2007 (After Completing Bridging Unit)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>N</td>
</tr>
<tr>
<td>Difficult science (3 point scale)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. You have to be clever to do science</td>
<td>1.7</td>
<td>72</td>
</tr>
<tr>
<td>7. Science is just too difficult</td>
<td>1.6</td>
<td>72</td>
</tr>
<tr>
<td>12. We have to do too much work in science</td>
<td>2.2</td>
<td>72</td>
</tr>
<tr>
<td>18. We do too much science at school</td>
<td>2.2</td>
<td>72</td>
</tr>
<tr>
<td>20. We have to do too much writing in science</td>
<td>2.5</td>
<td>73</td>
</tr>
</tbody>
</table>

*Note.* For each item differences were tested using two tailed t-tests *p<.05.*
and the composite scale of ‘Science interest’ (25 items comprising the sub-scales of ‘Independent investigator’, ‘Science enthusiast’ and ‘Social context’; max 75) were calculated. Means for these derived and composite scales were compared across the year seven cohorts (using independent t-tests).

As stated the Pupils’ Attitudes to Science instrument, used in this study, contains three scales. This questionnaire also includes two open-ended items, namely “a good thing about science” and “a bad thing about science”. Some responses to these two questions have been included in the results section (e).

**d. Problems Associated with the Implementation of this Bridging Unit and the Method of Analysis of the Attitudinal Surveys**

It is important at this stage to identify some of the problems associated with the Bridging Unit before looking further at the results of this study. All schools and teacher representatives were issued with copies of the attitudinal survey. However some teachers failed to conduct the attitudinal surveys with their students in year six, resulting in a small sample of attitudinal pre-surveys in 2006 of students who would actually be attending secondary school C. The majority of the students who completed the survey attended the Catholic school in the project, and the majority of these year six students went on to Catholic secondary schools in year seven, 2007. It would have been desirable to compare the results of the group of students prior to undertaking the bridging unit in 2006 with the same group of students’ results when in year seven in 2007 after completing the unit. However due to the small sample size for this survey as a result of teachers not carrying out the survey with their students, it was not possible to use these 2006 surveys in this project to obtain the longitudinal data. Cross-sectional data was compared from the surveys carried out between the year seven cohort of 2004 who had not completed a bridging unit of work and the year seven cohort in 2007 who had completed a bridging unit of work (see footnote 4 above under section 2c).

The largest feeder primary school (School A, Table 9.1) did not commence the bridging unit until the last few weeks of term four and failed to complete the unit due to time
constraints. At the end of term four in the final year of primary school, in Australia, students often begin to lose interest in their schoolwork as the Christmas season and festivities associated with it have commenced. Therefore it is not generally a productive time for teachers to introduce new units of work. However the majority of students completed the first four of the six lessons in this bridging unit in 2006 and the majority attended the laboratory session in the secondary school. Lack of enthusiasm of teachers in primary schools in the United Kingdom towards bridging programmes due to stresses of other commitments in the final year of primary schools, such as national testing has been identified as a problem associated with the administration of bridging units (Galton, 2002, cited in Braund & Hames, 2005). Although national testing is not an issue with primary teachers in Australia, the stresses of the final year of primary school and the heavy curriculum demands at the end of year six led to a break down of this bridging unit in some schools.

The secondary component of the bridging unit was designed to be implemented in term one 2007 to provide continuity and a link between primary and secondary science. Due to pragmatic difficulties the unit was not completed in secondary school until the end of term two, 2007. Only one of the practical lessons that were planned was presented (as mentioned above). Of the teachers who taught year seven in 2004 at the participant secondary school, only two taught year seven classes in 2007, therefore teaching style may have been a variable when comparing the attitudinal surveys between the cohorts of 2004 and 2007. One of the teacher representatives in the secondary school (School C) who had been responsible for designing the soil analysis lesson, was not appointed to a year seven class in 2007 and this lesson was subsequently deleted from the bridging unit.

There were changes of staff in the secondary school with two staff being transferred to other schools, including the School Science Co-ordinator who was also Co-ordinator of this project and the person who was the ‘driving force’ behind the project. A new Science Co-ordinator was appointed to the secondary school (School C) at the beginning of 2007. However the original Co-ordinator of the project, which included the bridging unit, continued in the role as project Co-ordinator (without receiving any release time from teaching for this task and while living outside the region) until the new Science
Co-ordinator was able to take on the position. After becoming involved in the project in second term, 2007 and taking over the role of Co-ordinator of the project, mid 2007, the new secondary Science Co-ordinator was keen to ensure the project would continue beyond the completion date. He intends to encourage innovative teaching practices amongst the science staff in the secondary school such as extensive use of the interactive whiteboard and more student-centred practical tasks where students have the opportunity to independently explore and investigate. He also plans, to conduct science activities where the year six and year seven students interact; organise CSIRO scientists to carry out science activities at the school each year; and ensure the secondary component of the bridging unit in 2008 will be carried out early in the year (and comprehensively).

Some year seven teachers in the secondary school were slow to embrace the interactive whiteboard technology (Fig. 9.1), which resulted in little use of this resource for the first two terms of 2007. This is an area that is improving as the teachers gain confidence with this resource and make more use of it as the year progresses.

**e. Comparison of Attitudinal Survey results of 2004/2005 Year Seven cohorts with the 2007 Year Seven Cohort after Completion of the Bridging Unit**

The results are presented under the following headings:

i. the results in general;

ii. difficult science;

iii. science interest;

iv. teachers/teaching practices; and

v. factors impacting on attitude which are in common with the 2004 attitudinal surveys and the 2004/2005 case study; and

vi. other matters relating to the results of the bridging unit and the project in general.

**(i) The Results in General**

Anecdotal evidence and observations of students suggested that students in both primary school and secondary school displayed motivation, and positive attitudes, towards the bridging unit activities. The students particularly enjoyed visits to the secondary school
in year six, and the institute to observe scientists at work in year seven. The students were also excited to observe photographs of themselves taking part in the activities in 2006 in a slide show presented later in year seven, prior to the secondary bridging unit lessons taking place. However the overall quantitative results of this attitudinal survey indicated that there was no significant difference in attitudinal scores between the students in 2007, and the year seven students in 2004 (these students in 2004 had not taken part in a bridging unit) (Table 9.2).

The students scores in the 2004 group (N=73) were compared with the means of the students who had completed the bridging unit in 2007 (N=143) and there was no significant difference between the groups in any of the following categories (see Table 9.2): ‘Independent investigator’ (year 7, 04, 20.9; year 7, 07, 20.4) t-test, p>0.05); ‘Science enthusiast’ (year 7, 04, 12.6; year 7, 07, 12.4: t-test, p>0.05); ‘Social context’ (year 7, 04, 18.6; year 7, 07, 18.6: t-test, p>0.05); ‘Science interest’ (year 7, 04, 52.2; year 7, 07, 51.4: t-test, p>0.05); and ‘Science difficulty’ (year 7, 04, 10.2; year 7, 07, 9.8: t-test, p>0.05).

(ii) Difficult Science

The ‘Difficult science’ subscale did show an overall significant increase from year six primary to year seven secondary in 2004 (Table 4.8, Chapter 4) (students perceiving science to be more difficult scored higher in this sub-scale). If the ‘Difficult science’ scores of the students in year six primary school in 2006 and those of the students in year six in 2004 were similar it could be suggested that the secondary students in 2007 also perceived science to be more difficult than they did in 2006 (when in year six) as the 2007 scores in this sub-scale revealed no significant difference to those in 2004 (see ‘Difficult science’ scores in Table 9.2). This is supported by comments to “a bad thing about science” from 2007 students such as, “science is too difficult”, “some topics are really boring and hard to understand”, “It’s too hard” (this comment may be an example where the word boring is used to describe a high level of difficulty for the student in contrast to science being unchallenging [Baird et al., 1990]). However with the individual item “We have to do too much writing in science” (Table 9.5) there was a significant difference (2004, 2.5; 2007, 2.3: two tailed t-test, p<0.05). In fact in 2007 the students felt more strongly in regard to
undertaking too much writing. This is supported by responses to “a bad thing about science” where 49% of 2007 students (70/143 students) responded with negative comments relating to writing (see further discussion about writing and copying of notes below).

(iii) Science Interest

The ‘Science interest’ composite scale was made up of a combination of ‘Independent investigator’, ‘Science enthusiast’, and ‘Social context’ scales (See tables 9.2, 9.3 & 9.4). There was a significant decline in science interest scores in the cross-sectional scores from year six primary to year seven secondary in ‘Science interest’ of students in 2004 (Table 4.8, Chapter 4) and also with the non case study participant students who took part in an attitudinal survey in 2005 (Table 5.2, Chapter 5). When looking at the individual items for each of the three sub-scales there were no items where there were significant differences between the means of the students in 2004 and those in 2007 (Table 9.3 & 9.4). As the students in year seven in 2007 ‘Science interest’ scores were not significantly different to students in 2004, it is possible that even though these students had participated in the bridging unit there was also a significant decline in science interest over the primary/secondary divide from 2006 to 2007. This is assuming the year six 2004 students, were similar in attitude to the year six students in 2006 in the participant schools. However this is an assumption and there is no way of determining this accurately. However a general lack of interest in science is supported by responses to the item “a bad thing about science” which included comments such as, “everything” (about science), “science is boring” and “science sux”. It is clear from the item “I like science more than any other school work” that science was not a favourite subject amongst many year seven students in either 2004 or 2007 (2004, 1.3; 2007, 1.3) (Table 9.4). However there were positive comments about science in response to “a good thing about science” such as “science is cool” and “everything”. The majority of positive comments from these year seven students related to practical aspects of science such as taking part in experiments (69% of students in 2007 [N=143]) responded with such a comment, see further comments about this issue in part iv) and using equipment such as the Bunsen burners. Some positive comments included working with friends.
(iv) Teachers/Teaching Practices

Looking at the responses to the open-ended item, “a bad thing about science”, relating to teachers and teaching practices, there were 14% (20/143) of negative teacher related responses. These included comments such as “the teacher yelling at the students”, “I don’t like the teacher” and the “the teacher talks (or lectures) too much”. There were five (3%, 5/143) positive comments to the item “a good thing about science” relating to the teacher (and the majority of these were where two teachers taught one science class and the students ‘liked’ one and ‘disliked’ the other).

Experiments and Practical Work

In response to a “good thing about science”, students performing “experiments” (including “practical work” or “hands on” science) was a practice that was enjoyed by 69% (99/143) of students. Out of these responses at least 17 students stated, “we do not do enough experiments”.

Writing or Copying of Notes

A common response to a ‘bad thing about science’ was “writing” (including “theory” and “bookwork”) where 49% of students (70/143 students) responded with comments relating to writing, for example, “listening to the teacher talking all day and not doing anything but writing in books”.

Student-Centred Learning

There was an indication from some of the ‘Science experiments’ scale items that the students in the 2007 survey would have liked their science activities to be more student-centred where they chose their own equipment (item mean, 3.9) (Table 9.3), found out what happened themselves (item mean, 4.1), worked with their friends (item mean, 4.6), and told their friends what they had done (item mean 3.5) (working with friends was also a response to “a good thing about science”). This is in contrast to the teacher telling the students what to do (item mean 2.9), or watching the teacher perform an experiment (item mean 2.9) (Table 9.3). This lower mean score relating to ‘watching the teacher perform experiments’ was backed up by the following response from a student in the 2007 survey to “a bad thing about science”: “watching the teachers do all the fun stuff”. One student
who stated that experiments such as dissecting animals were "a good thing about science" responded with "predictable, boring experiments" to "a bad thing about science".

**Learning new things and Repetition of Work**

At least 12 year seven students in 2007, stated that "learning new things" was a "good thing about science". These comments support those from the 2004 attitudinal survey and case study, where 29% of secondary students stated ‘learning new things in response to “a good thing about science” (Table 4.13, Chapter 4).

The following comment to “a bad thing about science” is worth noting: “We do too much at school. We do so much in primary school and then we come to high school and we know just about everything”. It was interesting to note that there was no positive or negative comments directly relating to activities participated in during the bridging unit even though this survey was conducted within two weeks of completing the bridging unit.

**(v) Factors Impacting on Attitude which are in Common with the 2004 Attitudinal Surveys and the 2004/2005 Case Study,**

The factors impacting on the students' attitudes in 2007 are the same factors apparent in both the attitudinal survey in 2004 and case study data from 2004/2005. It is evident from these results that students generally in 2007 were disappointed with their secondary science experience. These factors relate to pedagogy namely, too much copying of notes, not enough practical science, the dislike of practices such as teacher demonstrations, the dull presentation of large amounts of content, and repetition of work. Other factors relating to teaching style that were common to all studies were: students would prefer to have more opportunity to be active participants during science especially relating to practical work rather than being in a passive role. The majority of these students enjoyed the practical nature of science where they had the opportunity to take part in experiments and 'hands on' science rather than watching the teacher.
(vi) Other Matters Relating to the Results of the Bridging Unit and the Project in General

It could be said that this bridging unit was in part evaluated by a ‘one off’ post-only attitudinal survey and perhaps with more qualitative data a different picture may emerge. However as noted with the case study (Chapter 5) where comprehensive, multi methods of qualitative data were collected and analysed, in the majority of cases the qualitative data generally supported the quantitative data from this attitudinal survey. Therefore this survey would appear to be a reasonable indicator of students’ attitudes towards science. It is also important to emphasize that the pre-survey that was planned, did not eventuate so the longitudinal data of the science attitude scores across the primary/secondary interface could not be compared, only surmised.

The science interest scores of the students in this study were compared to an earlier cohort of students in year seven who had not completed a bridging unit. With the bridging unit planned for 2007/2008 (Figure 9.2), the project team are keen to see that attitudinal surveys are administered more extensively in year six and year seven, to enable analysis of pre-bridging unit and post-bridging unit attitudinal surveys to give a more accurate picture of what is occurring over the transition.

The teachers involved in this project are keen to address the issues raised in this study and are hoping that a different picture will emerge in 2008 and that students maintain positive attitudes towards science over the primary/secondary interface. The project team hope that this bridging unit and other initiatives as part of the project could provide a benchmark for other schools in the area including the Catholic secondary schools to ensure students in the year six primary schools have the opportunity to take part in the secondary component of the bridging unit.
(f) A Discussion relating to the results of the 2007 Attitudinal Survey and Comparisons of these results with those of the attitudinal survey in 2004 and the Case Study in 2004/2005

This section is divided into the following subsections:

i. the results and the bridging unit;

ii. other initiatives that may assist students to develop positive attitudes such as activity days carried out by pre-service teachers and resource kits; and

iii. implications for educators arising from the results of this bridging unit.

(i) The Results and the Bridging Unit

The results of this survey indicating no significant difference in attitude between the students in year seven 2004 who had not completed a bridging unit and the students in year seven 2007 who had completed the bridging unit were not unexpected due to the difficulties associated with the project (see section 2.d above). The bridging unit was quite comprehensive in primary school in 2006 and even though this unit was left to the last few weeks of year six in one of the schools, all the year six students took part in at least two or three stimulating science activities in their primary classes where they were encouraged to explore and investigate with writing of notes kept to a minimum. These year six students all took part in a visit to the secondary school where they participated in exciting activities, used new, sophisticated equipment (microscopes and interactive whiteboard), and carried out relevant science experiments (extracting DNA and researching the popular topic of genetics). These interesting activities in primary school combined with the exciting visit to the secondary school may have resulted in unrealistic expectations of secondary school science.

The Co-ordinator of science who initiated the project was transferred to another region for the last term of 2006. It appeared that the disruptions in the secondary school such as changes in staff were a distraction at the beginning of 2007 causing the bridging unit to be set-aside in first term. When this unit was implemented, it was cut short with only two of the planned lessons presented together with the visit to the institute to see scientists at work. Apart from the experience of visiting the secondary school with their teachers in year six, there was little continuity between primary and secondary school for these
students, as this was to be provided when the students took part in the bridging unit early in year seven. The students did not commence the secondary component of the bridging unit until late in term two. There is a chance that the students had already formed their attitudes towards secondary science by this stage, prior to taking part in the secondary component of the bridging unit. The smooth transition from primary into secondary science did not appear to eventuate for these students.

When comparing the findings of the 2004 attitudinal surveys and the 2004/2005 case study, with those of the 2007 attitudinal surveys, it appeared that little had changed in secondary school even though these students participated in the bridging unit. The interactive whiteboards were not used to a large extent in the year seven-science classes, and the majority of students believed that they were doing too much written work (most likely copying notes from the board). Many students thought that they were not doing enough practical work and some students complained that the teachers individually performed many of the ‘fun’ experiments as teacher demonstrations. Some students perceived science to be difficult in year seven. Comments relating to science being boring, repetition of work, and dissatisfaction with the teaching style and in some cases the teacher, were evident in 2007. In fact the picture that has emerged from this 2007 attitudinal survey is much the same as what was occurring in relation to teaching practices and perceptions of students revealed in the attitudinal survey in 2004 and the case study in 2005 (Chapters 4 & 5). Students often want to leave their primary school experiences behind when starting secondary school to be able to move on to new things and this is a problem that has been associated with bridging units where students may perceive they are taking a step back to primary school when carrying out the secondary component of the bridging unit (Galton, 2002, cited in Braund & Hames, 2005). It would seem that by carrying out the bridging unit later in the year, the students would have settled into secondary science and revisiting their primary experiences may not have been a productive experience.
(ii) Other Initiatives that May Assist Students to Develop Positive Attitudes

The following sections give two examples of initiatives that may assist in helping students maintain positive attitudes towards science.

Activities that May Influence Students’ Attitude to Science

Students in year six participated in ‘fun’ science activity days at primary school conducted by pre-service teachers from the local university (Figure 9.1). Perhaps encouraging such activities with groups of secondary pre-service teachers early in year seven may add to the students’ positive experiences.

The students involved in the 2007 attitudinal survey did not participate in the CSIRO science activities until after they completed the survey (Figure 9.2). However the year six students in 2007 who will be completing a bridging unit in 2008 will take part in the CSIRO activities with the year seven students. It is possible that the CSIRO activities could stimulate interest in science with the students in 2007 and enable these student to interact with scientists in a positive way. However it is hoped that participating in an exciting activity at the secondary school would not lead to unrealistic expectations of secondary school with the year six students.

Resource Kits

The science resource kits that were purchased were an the attempt to ensure students from different primary schools covered the same topics in science, and that the activities would complement the secondary science programme rather than risk repetition of work (Figure 9.1). Although these resource kits are being used by most feeder primary schools in 2007 some schools have chosen not to use the kits. These kits were not extensively used until the beginning of 2007 after the students in this bridging unit study had finished primary school. Therefore the students in year seven (2007) did not complete unified science topics in primary school prior to entering secondary school. A comment from a student in the 2007 attitudinal survey stated that they cover so much science in primary school that they already “know just about everything” presented in secondary school (see above under results). This comment suggests that there was repetition of this student’s
primary science work in secondary school. It is essential for secondary science teachers to elicit the students' prior knowledge and enquire about their primary science experience, rather than assuming that the students have little or no knowledge about each topic. Braund and Hames (2005) identified from the research literature that teachers failed to enquire about students' prior science experiences and understanding early in secondary school; they considered that this was a major factor leading to a decline in students' attitudes towards science over the primary/secondary interface.

(iii) Implications for Educators Arising from the Results of this Bridging Unit.

According to Tytler (2007a) “school and community-linked projects hold the promise of satisfying many of the conditions for an engaging and meaningful science education” (p.63). The ideas behind this project and bridging unit involving a partnership between primary, secondary and university teachers, and scientists in the community, were excellent. However it will take time and further pedagogical changes before any benefits of this project are likely to surface.

In this project it appeared that the 2006/2007 bridging unit did not help to provide a smooth transition into secondary school; instead it highlighted the divide between primary and secondary science. After taking part in the stimulating ‘crime busters’ activities in year six and the ‘one off’ exciting science laboratory session at the secondary school these students moved into year seven in 2007 possibly with high expectations of their science. It appeared that their secondary experience was a disappointment. Unless all teachers are prepared to embrace these bridging units, at primary and secondary level, these interventions will have little impact on students’ attitudes to science and could even result in disappointment for students. It was clear in this project that the secondary component of this bridging unit (and some aspects of the primary component) broke down and although classroom observations were not undertaken the attitudinal survey data reveals little difference in the students’ attitudes to the science pedagogy in 2007 compared to those in the 2004 attitudinal survey or the 2004/2005 case study.

In order for students to maintain positive attitudes towards science over the primary/secondary interface it is important that their teachers address the pedagogical
issues identified in this attitudinal study, particularly in secondary school. Being made aware of these issues before the project is officially completed has given the project team and teaching staff the opportunity to address these areas.

In the four years since the research outlined in this thesis commenced the concern over students' lack of interest in, motivation towards, and engagement in, science has been gathering momentum within the science education community in Australia (Holbrook, 2007; Tytler, 2007a). There have been a number of recent projects that have addressed this lack of interest in science where relevant issues have been investigated in science lessons resulting in student engagement and high levels of student satisfaction (Smith & Mitchell, 2007) and where teachers have been supported to implement innovative teaching practices in science (Tytler, 2007b). Tytler emphasized the importance of working in teams to address the issues surrounding science education; he also saw the importance of taking into account the individual style of teachers and the varying needs of students as there is no simplistic "one size fits all" solution to these problems (2007b, p. 214). Elements identified by Tytler as important in addressing the problems of decline in interest in science include: curriculum, resources, pedagogy, professional development, and school organisation (2007b, p. 214). The project outlined in this chapter has taken into account these elements. However although there is team approach within the school community it is essential that the majority of teaching staff from the schools involved are inspired to make a change not just the teachers represented on the project team.

It is hoped that the teachers (particularly the secondary teachers) with the assistance of the Science Co-ordinator can endeavour to trial practices that have been shown in research studies to result in student interest in science, motivation and engagement towards science lessons, and a positive attitude towards the subject. Many such practices have been identified throughout this thesis and are discussed in the following section. It would be beneficial for all secondary teachers (particularly those teaching years seven and eight) (in addition to the primary teachers, see Figure 9.2) to take part in professional development to encourage the implementation of student-centred science such as that advocated by enquiry-based, or problem-based, learning approaches.
Part 3

Attitudes, Interest, Motivation and Engagement; relating to the Studies Analysed in this Thesis

At this point in the thesis it seemed important to look at the outcome of the case study in relation to the results of the 2007 bridging unit and the 2004 attitudinal survey, and the factors associated with students' attitudes, interest, motivation and engagement.

Part three is divided into four sections under the following headings:

a. the 2004/2005 case study and 2007 attitudinal survey;
b. looking at how the constructs, attitude, interest, motivation and engagement, relate to the studies outlined in this thesis;
c. listening to the voice of the students; and
d. links between the constructs leading to a positive attitude towards science and a 'personal interest' in science.

a. The 2004/2005 Case Study and 2007 Attitudinal Survey

The majority of students in the case study (Chapter 5) in contrast to their non-participant peers, maintained a positive attitude to, and interest in, science in 2005. There was no initiative taken to impact on these students' attitudes, as part of the case study and it was an unexpected outcome. Although this bridging unit was implemented to create a smooth transition by providing familiarity and continuity, and a unit of work was designed to stimulate interest and highlight the relevance of science, these students in year seven 2007, did not reveal any significant difference in attitude to those of other year 7 students in 2004 where no bridging programme was implemented.

All case study participant students revealed their dislike of large amounts of written work and their love of practical science, particularly where the students were in control of their own learning. High expectations from teachers regarding the students' work, heavy

\footnote{It should be noted that there was no significant difference in the 'Science interest' scores when in year six (2004) between the case study students and their non-participant peers in 2004 (Table 5.5, Chapter 5).}
content, and science that was teacher-centred where students were told the results of experiments before performing them and were not given the opportunity to explore and investigate, were practices that these students identified as frustrating. However there was something that led to these case study participant students maintaining their positive attitudes towards the subject (Chapter 7) and some of these factors are discussed in the following section.

b. Looking at How the Constructs: Attitude, Interest, Motivation and Engagement, Relate to the Studies Outlined in this Thesis

If school science is to stimulate student interest, and science activities are to initiate student motivation and engagement, and science lessons are to generally encourage students to develop positive attitudes towards the subject, we need to look at the common factors that impact on these constructs (Chapter 2, figures, 2.1 & 2.2); these are outlined in the following:

- pedagogy emerges as being a major factor influencing these constructs (Harlen, 2003a, Palmer, 2007a; Pugh, 2004; Simon, 2000) and this is supported (loud and clear) in the studies outlined in this thesis;
- self-esteem is another important factor associated with these constructs (Harlen, 2003a, Palmer, 2007a; Pugh, 2004; Simon, 2000) and as the students in the case study were given a voice, their ideas and opinions were taken seriously, the researcher took an interest in each of these students in both primary school and in secondary school, then it is possible that they felt valued in science and developed a positive self-esteem towards the subject;
- social involvement and peer support were linked to these constructs (Harlen, 2003a, Palmer, 2007a; Pugh, 2004; Simon, 2000) and in the case study, being part of the study participant group, may have influenced these students’ attitudes towards science. It is evident in the case study and attitudinal surveys in 2004 and 2007 that students value working with their peers in science;
- parent or home support was related to these constructs (Harlen, 2003a, Pugh, 2004; Simon, 2000) and although there was no evidence to assess whether the students in these studies were receiving parental encouragement in science it is worth considering ways to enthuse parents about their children’s science experience by informing them about projects such as the bridging unit and improving
teacher/parent communication. As the students in the case study required parental permission to participate in the study, perhaps these parents took more interest in their students’ science experience as a result of the study. The survey of the parents of the case study participants did reveal that the majority of parents who completed the survey (N=15; 75% response rate, one or both parents) stated that they liked school science (particularly the practical aspects of the subject); and

- motivation towards the subject is related to all other constructs (Palmer, 2007a; Pintrich and De Groot, 1990; Simon, 2000); therefore in order for students to develop an interest in, a positive attitude to, and engagement with science activities, it is important for students to be motivated towards their science. The majority of participant students in the case study appeared motivated towards science during the science class observations in both primary and secondary school, particularly during practical science lessons. These case study students also appeared motivated towards the science activities conducted during the focus groups (see Appendix I for narratives describing each participant student at both primary school and secondary school).

c. Listening to the Voice of the Students.

It is essential that teachers listen to the voice of the student and take note of practices identified in the findings of the case study that led to students maintaining their positive attitudes to science, particularly early in secondary school, and also be aware of practices in the 2004 and 2007 attitudinal surveys that led to students’ attitudes becoming less positive towards science. The students in these studies have identified teaching practices that do lead to a positive attitude to, and an interest in, science; the following list is a summary of these practices:

- developing curricula that are relevant to the students’ own lives and the 21st Century;
- providing stimulating science activities where students explore and investigate, in contrast to teacher-centred recipe-like practical lessons where results of experiments are revealed before the students undertake them;
- taking the students’ ideas seriously and giving credence to student voice;
• respecting that students have prior knowledge in science in order to avoid repetition of work which may lead to boredom;
• providing opportunities that lead to students feeling valued, and avoid practices that result in students feeling humiliated or frustrated;
• initiating student discussion, particularly as to the relevance of learning science in school and debating current issues in science, in contrast to lecturing to the students about science content;
• providing clear, concise explanations;
• encouraging students to work collaboratively with peers;
• providing content that is challenging but enables all students to achieve successes in science (students perceiving science to be more difficult appears to be associated with declining attitudes towards the subject);
• avoiding rushing through content;
• reducing the amount of written work and mindless copying of notes by the use of technologies such as computers and interactive whiteboards;
• enhancing other technologies in the science classroom such as encouraging students to use digital or video cameras to record information, to use interactive CD-ROMs, or to view animations for the illustration of conceptual ideas;
• improving parent/teacher communication to encourage parents to take an interest in their child’s school science experience;
• ensuring there is familiarity and continuity across the primary/secondary divide; and (most importantly)
• taking a step back and allowing the students to take control of their own learning, have their say in the planning of the programme or choice of topics, and providing opportunities for student to design and carry out their own investigations in science.

It is hoped that the majority of year six students who take part in the second bridging project which will commence at the end of their primary school in 2007 and go through to the beginning of secondary school in 2008 will experience pedagogy that embraces the factors identified and perhaps the majority of these students will maintain positive attitudes towards science like most of the case study participants in 2005.
Chapter Nine

d. Links between the Constructs leading to a Positive Attitude towards Science and a ‘Personal Interest’ in Science.

If students’ ‘situational interest’ is stimulated in science lessons, and motivation towards, and engagement in, science activities, is encouraged, it is possible that they will develop positive attitudes towards the subject (Fig 2.2, Chapter 2). In order to develop or sustain a ‘personal interest’ in science (Hidi, 1990), and ‘engagement with content’ (Pugh, 2004) in the subject (Fig.2.2, Chapter 2) it is important that students maintain positive attitudes towards the science when moving from primary into secondary school (Fig 2.2, Chapter 2). If students retain or develop a ‘personal interest’ in science and positive attitude towards the subject through secondary school then it is more likely that they will choose science subjects in senior secondary school and/or pursue science careers (Lindahl, 2003); this may be contrasted with students developing negative attitudes towards, and losing interest in, the subject. Taking note of the findings in these studies and implementing the teaching practices outlined above would be positive steps towards addressing the problems of declining numbers of students choosing science subjects in senior school and declining numbers of students pursuing science careers.

Concluding Notes

It was encouraging that my research projects associated with this thesis inspired teachers in the schools involved to make an attempt to address the problems identified in the research. Certainly there is a growing awareness of the importance of teaching science in primary schools amongst these teachers and a keenness to embrace new teaching styles such as those advocated in the Primary Connections resources (Academy of Science, 2006). There has also been an interest by some secondary teachers to address issues that have surfaced in the 2007 study relating to teaching practices. Even though problems with this project have been identified and the year seven students’ attitudes in 2007 remain similar to those students who did not participate in the bridging unit in 2004, it is a positive sign that the teachers are taking note of these issues. It also shows the significance and importance of conducting research in schools and how the findings can stimulate change within the participant schools in addition to influencing the teaching profession through the publishing of results. It is anticipated that the results of the attitudinal study in 2007 will not deter teachers from trialling practices to address the issues surrounding students’
science over the primary/secondary interface; rather these findings will hopefully encourage teachers to listen to the voice of the students and facilitate science that inspires and captures the students’ interest. The science education research literature demonstrates that once students lose interest in science and develop a negative attitude towards the subject it is difficult to turn these attitudes around (Gibson & Chase, 2002; Lindahl, 2003).

As an experienced teacher in secondary science I am all too familiar with the heavy curricula in the subject and the expectations of parents. This should not be an excuse for continuing the practices that have bored students for decades. The results of the attitudinal surveys undertaken as part of this thesis have supported numerous other studies where students’ positive attitudes to science have declined over the primary/secondary interface. However the case study data revealed that the majority of the 20 participant students maintained their interest in, and positive attitudes towards, science. The findings from these studies have also supported the scientific education research literature in identifying factors that lead to a positive attitudes to, and interest in, in science.

It is up to us as science educators to inspire and encourage interest in, motivation towards, engagement in, and a positive attitude to, science, as science is an integral part of life and so highly relevant to the 21st Century. There is a crisis in science and we as educators have the opportunity to make a difference.

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1 Research question 1 in the attitudinal survey and case study: How do students’ attitudes to, and interest in, science change as they move from primary school into high school?
2 Research question 2 in the attitudinal survey and case study: What are the factors that affect the changes in attitude and interest towards science?
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Narrative for Leigh ................................................................................... 349
  Leigh: Year Six, Primary School, 2004 (6S) ........................................ 349
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Narrative for Martin ................................................................................ 351
  Martin: Year Six, Primary School, 2004 (6H) ...................................... 351
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  Roxy: Year Six, Primary School, 2004 (6T) ........................................... 355
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  Tatiana: Year Six, Primary School, 2004 (6S) ...................................... 358
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Narrative for Tia: ..................................................................................... 360
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  Tyson: Year Six, Primary School, 2004 (6H) ....................................... 362
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APPENDIX A

Interview Questions for Semi-Structured Interview with Individual Students

1. What sort of things do you like to do when you are not at school? (Reiss, 2000).
2. Why do you like doing these things?
3. What are your favourite subjects at school?
4. What have you been doing in science at school? (Reiss, 2000).
6. Why do you like doing these things?
7. Is there anything you find difficult to do in science? (Murphy & Beggs, 2003).
8. What don’t you like about science lessons? (Rennie, Hackling & Goodrum, 1999 [as cited in Goodrum, Hackling and Rennie, 2001, p. 215]).
9. Why don’t you like doing these things?
11. If you were in charge of planning science for your class, what sort of science lessons would you plan?
12. How would you compare science in primary school to science in secondary school? (This question was asked when students were in year seven).
APPENDIX B

Some Ideas to Stimulate Discussion in the Focus Groups

The children were encouraged to take part in activities such as: observing an egg pushing into a bottle as a result of air pressure; playing with pre-made slime; and watching a water rocket propelled. These activities were undertaken to help the children to relax and feel at ease.

Some Sample Questions

2. Why do you like doing these things?
4. Why don’t you like doing these things?
5. If you were in charge of planning a science lesson for your class what would you do?
6. If you were in charge of planning a science lesson for your class what wouldn’t you do?
APPENDIX C

Survey Questions for Parents.

Name of your Child who is involved in the study:

1. Did you like doing science in school and if so why?

2. Do you think science should be a compulsory subject for children of all ages?

3. Could you tell me why or why not please?

4. What “sort of science” do you think should be taught in
   a. primary school?
   b. lower secondary

Thank you for completing my survey.
APPENDIX D

Short Survey Questions for Student Participants

Could you please answer the questions below: Thankyou so much.

1. What did you like doing in science?

2. Why did you like doing it?

3. Why are you interested in still doing it?

4. Is there anything in science that you don’t like doing?

5. (If so) Why don’t you like doing it?

(Jo & Song, 2003; Rennie, Hackling & Goodrum, 1999, [as cited in Goodrum, Hackling and Rennie, 2001, p. 215]).
APPENDIX E

Attitudinal Survey for use with years 5, 6, 7, 8, 9 and 10.

The Permission of Dr A.W. PellUniversity of Leicester, England has been sought. University of Leicester /Astra Zeneca

*The instrument below has been adapted for the current research*

Pupils' attitudes to science

**Coming to school ? Science ? Science experiments ? What do you think about it all ?**

Name: ...............................  
I am a ............................... (boy/girl)  
My Year is..............................  
My School is...........................  

When you come to a question, answer with a tick on the SMILEY face! Like this....

**How do you feel about**

<table>
<thead>
<tr>
<th></th>
<th>Like it a lot</th>
<th>Like it a bit</th>
<th>Not sure</th>
<th>Don't like it very much</th>
<th>Hate it</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Watching television</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### Being in school

Here are some questions about what you do at school. **How do you feel about.....**

<table>
<thead>
<tr>
<th></th>
<th>Like it a lot</th>
<th>Like it a bit</th>
<th>Not sure</th>
<th>Don't like it very much</th>
<th>Hate it</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Writing</td>
<td>☑️</td>
<td>☑️</td>
<td>☐️</td>
<td>☐️</td>
</tr>
<tr>
<td>2</td>
<td>Reading</td>
<td>☑️</td>
<td>☑️</td>
<td>☐️</td>
<td>☐️</td>
</tr>
<tr>
<td>3</td>
<td>Spelling</td>
<td>☑️</td>
<td>☑️</td>
<td>☐️</td>
<td>☐️</td>
</tr>
<tr>
<td>4</td>
<td>Drawing</td>
<td>☑️</td>
<td>☑️</td>
<td>☐️</td>
<td>☐️</td>
</tr>
<tr>
<td>5</td>
<td>Doing maths</td>
<td>☑️</td>
<td>☑️</td>
<td>☐️</td>
<td>☐️</td>
</tr>
<tr>
<td>6</td>
<td>Working with shapes (geometry)</td>
<td>☑️</td>
<td>☑️</td>
<td>☐️</td>
<td>☐️</td>
</tr>
<tr>
<td>7</td>
<td>Using the computer</td>
<td>☑️</td>
<td>☑️</td>
<td>☐️</td>
<td>☐️</td>
</tr>
<tr>
<td>8</td>
<td>Doing science experiments</td>
<td>☑️</td>
<td>☑️</td>
<td>☐️</td>
<td>☐️</td>
</tr>
<tr>
<td>9</td>
<td>Writing in your science book</td>
<td>☑️</td>
<td>☑️</td>
<td>☐️</td>
<td>☐️</td>
</tr>
<tr>
<td>10</td>
<td>Working by yourself</td>
<td>☑️</td>
<td>☑️</td>
<td>☐️</td>
<td>☐️</td>
</tr>
<tr>
<td>11</td>
<td>Working with your friends</td>
<td>☑️</td>
<td>☑️</td>
<td>☐️</td>
<td>☐️</td>
</tr>
<tr>
<td>12</td>
<td>Coming to school</td>
<td>☑️</td>
<td>☑️</td>
<td>☐️</td>
<td>☐️</td>
</tr>
</tbody>
</table>

Please go to the next page ..........................

---

288
## Science experiments

Here are some questions about doing science. **How do you feel about...............**

<table>
<thead>
<tr>
<th></th>
<th>Like it a lot</th>
<th>Like it a bit</th>
<th>Not sure</th>
<th>Don't like it very much</th>
<th>Hate it</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Watching the teacher do an experiment</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Working out what to do yourself</td>
<td>2</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Teacher telling you what to do</td>
<td>3</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Choosing your own equipment</td>
<td>4</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. Finding out what happens to yourself</td>
<td>5</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. Working by yourself</td>
<td>6</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7. Working with friends</td>
<td>7</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8. Finding out why the experiment works</td>
<td>8</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9. Telling teacher what you have done</td>
<td>9</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10. Telling friends what you have done</td>
<td>10</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Please go to the next page .........................
What I really think of science

Here are some views about science and its place in the world.

<table>
<thead>
<tr>
<th>Do you agree</th>
<th>disagree</th>
<th>or are you not sure</th>
<th>Agree</th>
<th>Not sure</th>
<th>Disagree</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. I should like to be a scientist</td>
<td><img src="1" alt="Smiley" /></td>
<td><img src="2" alt="Disappointed" /></td>
<td><img src="3" alt="Neutral" /></td>
<td><img src="1" alt="Neutral" /></td>
<td><img src="2" alt="Neutral" /></td>
</tr>
<tr>
<td>2. Science is good for everybody</td>
<td><img src="1" alt="Smiley" /></td>
<td><img src="2" alt="Neutral" /></td>
<td><img src="3" alt="Neutral" /></td>
<td><img src="1" alt="Neutral" /></td>
<td><img src="2" alt="Neutral" /></td>
</tr>
<tr>
<td>3. Lots more money should be spent on science</td>
<td><img src="1" alt="Smiley" /></td>
<td><img src="2" alt="Neutral" /></td>
<td><img src="3" alt="Neutral" /></td>
<td><img src="1" alt="Neutral" /></td>
<td><img src="2" alt="Neutral" /></td>
</tr>
<tr>
<td>4. You have to be clever to do science</td>
<td><img src="1" alt="Smiley" /></td>
<td><img src="2" alt="Neutral" /></td>
<td><img src="3" alt="Neutral" /></td>
<td><img src="1" alt="Neutral" /></td>
<td><img src="2" alt="Neutral" /></td>
</tr>
<tr>
<td>5. I like science more than any other school work</td>
<td><img src="1" alt="Smiley" /></td>
<td><img src="2" alt="Neutral" /></td>
<td><img src="3" alt="Neutral" /></td>
<td><img src="1" alt="Neutral" /></td>
<td><img src="2" alt="Neutral" /></td>
</tr>
<tr>
<td>6. I often do science experiments at home</td>
<td><img src="1" alt="Smiley" /></td>
<td><img src="2" alt="Neutral" /></td>
<td><img src="3" alt="Neutral" /></td>
<td><img src="1" alt="Neutral" /></td>
<td><img src="2" alt="Neutral" /></td>
</tr>
<tr>
<td>7. Science is just too difficult</td>
<td><img src="1" alt="Smiley" /></td>
<td><img src="2" alt="Neutral" /></td>
<td><img src="3" alt="Neutral" /></td>
<td><img src="1" alt="Neutral" /></td>
<td><img src="2" alt="Neutral" /></td>
</tr>
<tr>
<td>8. It is easy to find out new things in science lessons</td>
<td><img src="1" alt="Smiley" /></td>
<td><img src="2" alt="Neutral" /></td>
<td><img src="3" alt="Neutral" /></td>
<td><img src="1" alt="Neutral" /></td>
<td><img src="2" alt="Neutral" /></td>
</tr>
<tr>
<td>9. Science has made us better and safer medicines</td>
<td><img src="1" alt="Smiley" /></td>
<td><img src="2" alt="Neutral" /></td>
<td><img src="3" alt="Neutral" /></td>
<td><img src="1" alt="Neutral" /></td>
<td><img src="2" alt="Neutral" /></td>
</tr>
<tr>
<td>10. TV, telephones and radio have all needed science</td>
<td><img src="1" alt="Smiley" /></td>
<td><img src="2" alt="Neutral" /></td>
<td><img src="3" alt="Neutral" /></td>
<td><img src="1" alt="Neutral" /></td>
<td><img src="2" alt="Neutral" /></td>
</tr>
<tr>
<td>11. Our food is safer thanks to science</td>
<td><img src="1" alt="Smiley" /></td>
<td><img src="2" alt="Neutral" /></td>
<td><img src="3" alt="Neutral" /></td>
<td><img src="1" alt="Neutral" /></td>
<td><img src="2" alt="Neutral" /></td>
</tr>
<tr>
<td>12. We have to do too much work in science</td>
<td><img src="1" alt="Smiley" /></td>
<td><img src="2" alt="Neutral" /></td>
<td><img src="3" alt="Neutral" /></td>
<td><img src="1" alt="Neutral" /></td>
<td><img src="2" alt="Neutral" /></td>
</tr>
<tr>
<td>13. I like to watch science programmes on TV</td>
<td><img src="1" alt="Smiley" /></td>
<td><img src="2" alt="Neutral" /></td>
<td><img src="3" alt="Neutral" /></td>
<td><img src="1" alt="Neutral" /></td>
<td><img src="2" alt="Neutral" /></td>
</tr>
<tr>
<td>14. School science clubs would be a good idea</td>
<td><img src="1" alt="Smiley" /></td>
<td><img src="2" alt="Neutral" /></td>
<td><img src="3" alt="Neutral" /></td>
<td><img src="1" alt="Neutral" /></td>
<td><img src="2" alt="Neutral" /></td>
</tr>
<tr>
<td>15. Science makes me think</td>
<td><img src="1" alt="Smiley" /></td>
<td><img src="2" alt="Neutral" /></td>
<td><img src="3" alt="Neutral" /></td>
<td><img src="1" alt="Neutral" /></td>
<td><img src="2" alt="Neutral" /></td>
</tr>
<tr>
<td>16. I am always reading science stories</td>
<td><img src="1" alt="Smiley" /></td>
<td><img src="2" alt="Neutral" /></td>
<td><img src="3" alt="Neutral" /></td>
<td><img src="1" alt="Neutral" /></td>
<td><img src="2" alt="Neutral" /></td>
</tr>
<tr>
<td>17. I should like to be given a science kit as a present</td>
<td><img src="1" alt="Smiley" /></td>
<td><img src="2" alt="Neutral" /></td>
<td><img src="3" alt="Neutral" /></td>
<td><img src="1" alt="Neutral" /></td>
<td><img src="2" alt="Neutral" /></td>
</tr>
<tr>
<td>18. We do too much science at school</td>
<td><img src="1" alt="Smiley" /></td>
<td><img src="2" alt="Neutral" /></td>
<td><img src="3" alt="Neutral" /></td>
<td><img src="1" alt="Neutral" /></td>
<td><img src="2" alt="Neutral" /></td>
</tr>
<tr>
<td>19. Science can make chemicals we need from rocks</td>
<td><img src="1" alt="Smiley" /></td>
<td><img src="2" alt="Neutral" /></td>
<td><img src="3" alt="Neutral" /></td>
<td><img src="1" alt="Neutral" /></td>
<td><img src="2" alt="Neutral" /></td>
</tr>
<tr>
<td>20. We have to do too much writing in science</td>
<td><img src="1" alt="Smiley" /></td>
<td><img src="2" alt="Neutral" /></td>
<td><img src="3" alt="Neutral" /></td>
<td><img src="1" alt="Neutral" /></td>
<td><img src="2" alt="Neutral" /></td>
</tr>
</tbody>
</table>
One day, I should like to go to the Moon.

Please write about science on the lines below:

A good thing about science

A bad thing about science

Did you answer every one? You did? Then, you have finished!

Thank you very much 😊 and good luck! .......

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## APPENDIX F

**A Sample of a Table of Individual Responses From High Ability Female Students; Combining Data from Interviews, Focus Groups, Short Survey Questions and the Open Responses on the Attitudinal Survey.**

### Attitudes and Interest in Science – Year six Primary School, Year seven High School: Female, High Ability, Combined Responses

<table>
<thead>
<tr>
<th>Student</th>
<th>School Year</th>
<th>Interview</th>
<th>Written Responses</th>
<th>Focus Group</th>
<th>Attitudinal Questionnaire</th>
</tr>
</thead>
<tbody>
<tr>
<td>Belinda</td>
<td>Year six</td>
<td>Like to learn different things about things I didn't know about a subject then going home and finding out more</td>
<td>Learning about things like plants, animals and the Earth and why and how things work.</td>
<td>Goo (slime) making things (I was going to say that - finding out about different things.</td>
<td>Learning a lot of new stuff that I didn't know.</td>
</tr>
<tr>
<td>Belinda</td>
<td>Year seven</td>
<td>pracs, doing all the experiments and stuff.</td>
<td>yeah experiments</td>
<td></td>
<td>Doing heaps of experiments in science</td>
</tr>
<tr>
<td>Tia</td>
<td>Year six</td>
<td>Like learning about some of those things cause like especially to do with animals and the earth and stuff</td>
<td>experiments and some subjects</td>
<td>(making things) yes</td>
<td>I like learning about some of the science subjects as they are interesting.</td>
</tr>
<tr>
<td>Tia</td>
<td>Year seven</td>
<td>experiments</td>
<td>experiments</td>
<td>Experiments</td>
<td>experiments</td>
</tr>
<tr>
<td>Cara</td>
<td>Year six</td>
<td>I like finding out different things and stuff.</td>
<td>Interesting stuff, learning new things.</td>
<td>Making things and finding out about things and experimenting with stuff.</td>
<td>You learn about new and interesting things. It is also fun when I do experiments.</td>
</tr>
<tr>
<td>Student</td>
<td>School Year</td>
<td>Interview</td>
<td>Written Responses</td>
<td>Focus Group</td>
<td>Attitudinal Questionnaire</td>
</tr>
<tr>
<td>---------</td>
<td>-------------</td>
<td>-----------</td>
<td>-------------------</td>
<td>-------------</td>
<td>--------------------------</td>
</tr>
<tr>
<td>Cara</td>
<td>Year seven</td>
<td>I don’t know it is probably more interesting and there is not as much copying from the board. We do the experiments and stuff.</td>
<td>Experiments and watching videos.</td>
<td>Is that we do experiments and learn new stuff.</td>
<td></td>
</tr>
<tr>
<td>Leigh</td>
<td>Year six</td>
<td>I like chemistry stuff, I like experiments.</td>
<td>Experiments</td>
<td>Is doing experiments</td>
<td></td>
</tr>
<tr>
<td>Leigh</td>
<td>Year seven</td>
<td>They are interesting usually and you don’t do the same thing over and over again.</td>
<td>Experiments</td>
<td>Its fun and a break from writing when doing experiments.</td>
<td></td>
</tr>
<tr>
<td>Alana</td>
<td>Year six</td>
<td>I think I love everything about science. I loved doing the subject on soil because its so interesting by what it can form</td>
<td>Science is different to everything else that we do. That’s good (writing down what you have learnt) because you keep remembering it, that’s what I like about it.</td>
<td>Science is helping us cure many deadly sicknesses</td>
<td></td>
</tr>
<tr>
<td>Alana</td>
<td>Year seven</td>
<td>I like doing experiments except we hardly ever do them any more. We used to do a lot but now we just write and yeh.</td>
<td>I just like doing any experiments, probably magnets. (Burning magnesium) yeh that was cool.</td>
<td>It’s discovering that the world is full of so many things. I have never seen/heard of before</td>
<td></td>
</tr>
<tr>
<td>Tatiana</td>
<td>Year six</td>
<td>I don’t know Probably living things</td>
<td>Experiments</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

293
<table>
<thead>
<tr>
<th>Student</th>
<th>Year</th>
<th>Interview</th>
<th>Written Responses</th>
<th>Focus Group</th>
<th>Attitudinal Questionnaire</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anne Year six</td>
<td>The experiments</td>
<td>The “experiments” <em>(spelling retained)</em></td>
<td>They are different to every other science lesson that we do. We do maths and English but not as much science.</td>
<td>It always changes</td>
<td></td>
</tr>
<tr>
<td>Anne Year seven</td>
<td>Probably experiments still</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. What do you like about science (a good thing about science)?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Belinda Year six</td>
<td></td>
<td></td>
<td>Because it’s fun to learn about things I like and how thy live, work or move.</td>
<td>Different ways of doing things.</td>
<td></td>
</tr>
<tr>
<td>Belinda Year seven</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tia Year six</td>
<td>I’m interested in finding that (earth and animals and stuff)</td>
<td>Interesting.</td>
<td></td>
<td>Doing science can be time consuming</td>
<td></td>
</tr>
<tr>
<td>Tia Year seven</td>
<td>it is better than just writing, and most of the time it is pretty fun</td>
<td>Fun better than writing</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cara Year six</td>
<td></td>
<td>Because it is fun and interesting.</td>
<td>(others - cause it is fun) yes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cara Year seven</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Leigh Year six</td>
<td>You get to mix weird substances together and see what happens</td>
<td>Because it is fun.</td>
<td>Cause it is fun.</td>
<td></td>
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</tr>
<tr>
<td>Leigh Year seven</td>
<td></td>
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</tbody>
</table>
### Appendices

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<tr>
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<tbody>
<tr>
<td>Alana</td>
<td>Year six</td>
<td>I think you learn a lot more by actually doing it instead of just writing or reading and it’s a lot funner.</td>
<td>Because I love anything to do with farming and agriculture.</td>
<td>Its like people have done it for so many years and its just interesting that school kids can learn about it too.</td>
<td></td>
</tr>
<tr>
<td>Alana</td>
<td>Year seven</td>
<td>I think you learn a lot more by actually doing it instead of just writing or reading and it’s a lot funner.</td>
<td>Because it is easier to understand things and it is fun.</td>
<td>You get to do hands on things like experiments</td>
<td></td>
</tr>
<tr>
<td>Tatiana</td>
<td>Year six</td>
<td>Because like I don’t know,</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tatiana</td>
<td>Year seven</td>
<td>Because like I don’t know,</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Anne</td>
<td>Year six</td>
<td>Its just something different to everything else you learn at school, yeah its just something different.</td>
<td>Because I didn’t have to write during it at all and it always changes so I never get bored.</td>
<td>Its not as much writing as every other thing. English and maths is always the same science always changes.</td>
<td>Its just something different to everything else you learn at school, yeah its just something different.</td>
</tr>
<tr>
<td>Anne</td>
<td>Year seven</td>
<td>Because you get to do stuff instead of sitting there and writing from off the board for the entire lesson.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Belinda</td>
<td>Year six</td>
<td>Nothing not really</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Belinda</td>
<td>Year seven</td>
<td>Nothing not really</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tan</td>
<td>Year six</td>
<td>Sometimes it’s a little bit hard, it’s hard to find good things on the internet for my work.</td>
<td></td>
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<tr>
<td>Student</td>
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</tr>
<tr>
<td>Tia</td>
<td>Year seven</td>
<td>not really</td>
<td></td>
<td></td>
<td>I don’t think I dislike anything about science.</td>
</tr>
<tr>
<td>Cara</td>
<td>Year six</td>
<td>Just getting the information, like trying to find it from everywhere.</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Cara</td>
<td>Year seven</td>
<td>not really unless they are talking about stuff that I really have no idea about.</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Leigh</td>
<td>Year six</td>
<td>Not really</td>
<td></td>
<td></td>
<td>Because it show what happens when you mix certain things.</td>
</tr>
<tr>
<td>Leigh</td>
<td>Year seven</td>
<td>Not really</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Alana</td>
<td>Year six</td>
<td>-</td>
<td>-</td>
<td>-</td>
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</tr>
<tr>
<td>Alana</td>
<td>Year seven</td>
<td>A lot of the terms. We have to learn so many terms but the same they are so confusing.</td>
<td></td>
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</tr>
<tr>
<td>Tatiana</td>
<td>Year six</td>
<td>Not really but we did a science test about electricity and there were some things I don’t really understand</td>
<td></td>
<td></td>
<td>Some of it can be really boring, like I didn’t enjoy learning about rocks that much.</td>
</tr>
<tr>
<td>Tatiana</td>
<td>Year seven</td>
<td>Remembering all the like different ways like separating mixtures and remembering all those different ways and yeh.</td>
<td></td>
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<tr>
<td>Anne</td>
<td>Year six</td>
<td>Measuring, I am hopeless at measuring.</td>
<td></td>
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<td>Student</td>
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</tr>
<tr>
<td>Belinda</td>
<td>Year six</td>
<td>Nothing really</td>
<td>No (nothing)</td>
<td>Time consuming</td>
<td>No response</td>
</tr>
<tr>
<td>Tia</td>
<td>Year six</td>
<td>Sometimes it's really hard and it takes a long time</td>
<td>No (nothing)</td>
<td>I hate the teacher talking too long about the one subject. When he explains all this stuff to us.</td>
<td></td>
</tr>
<tr>
<td>Tia</td>
<td>Year seven</td>
<td>No (nothing)</td>
<td>Lots of writing.</td>
<td>Just when you do lot's and lots of writing one day.</td>
<td></td>
</tr>
<tr>
<td>Cara</td>
<td>Year six</td>
<td>I don't know.</td>
<td>Having to spend lots of time finding research.</td>
<td>I don't like theory, like writing in our books, it sucks. Cause you like, if you stop for a second then you have heaps and heaps of stuff to do, cause they just keep writing it is really annoying and I don't like writing.</td>
<td></td>
</tr>
<tr>
<td>Cara</td>
<td>Year seven</td>
<td>oh its okay if there is only little amounts of stuff on the board and I don't like looking things up.</td>
<td>Is that we do too much writing.</td>
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</tr>
</tbody>
</table>

4. What don't you like about science (a bad thing about science).
<table>
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</tr>
</thead>
<tbody>
<tr>
<td>Leigh</td>
<td>Year seven</td>
<td>maybe a bit less writing stuff down, but it is not that much</td>
<td>Writing</td>
<td>Not really. Yeh that's annoying (lot's of writing).</td>
<td>We don't do enough experiments</td>
</tr>
<tr>
<td>Alana</td>
<td>Year six</td>
<td>Sometimes there are very scientific words that I don't understand.</td>
<td>Sometimes I don't understand.</td>
<td>It takes too long to discover cures.</td>
<td></td>
</tr>
<tr>
<td>Alana</td>
<td>Year seven</td>
<td>Practically we do just a lot of writing now and it's a lot harder to understand cause we are getting into much more difficult things. It's hard to process them in my brain all at once.</td>
<td></td>
<td>We have to do too much writing and sometimes I can't keep up.</td>
<td></td>
</tr>
<tr>
<td>Tatiana</td>
<td>Year six</td>
<td>I don't really care, I don't hate it.</td>
<td>Because some of the things you do like scratching a rock nothing happened, and that's what happens in a lot of experiments, but I guess that's what a lot of scientists do and they probably get frustrated if nothing happens.</td>
<td>Yeh! then you have to write down everything you have learnt when you have actually.</td>
<td>You have to write down everything that happened afterwards.</td>
</tr>
<tr>
<td>Tatiana</td>
<td>Year seven</td>
<td>Writing.</td>
<td></td>
<td>The technical words. I don't like summarising and stuff. I hate how the drawings have to be yeh perfect and that.</td>
<td>It's really boring and it's experiments we do are boring.</td>
</tr>
<tr>
<td>Student</td>
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</tr>
<tr>
<td>Anne</td>
<td>Year seven</td>
<td>Writing</td>
<td>I hate having to write it out in the right format when we are writing the reports.</td>
<td>That you have to be so exact or something will go wrong.</td>
<td></td>
</tr>
<tr>
<td>4. What don't you like about science (a bad thing about science).</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Belinda</th>
<th>Year six</th>
<th>-</th>
<th>Everybody explains it the difficult way.</th>
</tr>
</thead>
<tbody>
<tr>
<td>5. Why don't you like it?</td>
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</table>

<table>
<thead>
<tr>
<th>Belinda</th>
<th>Year seven</th>
<th>It is pretty boring</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tia</td>
<td>Year six</td>
<td>Cause I don't have time to do my other homework and on weekends I have to catch up on my other homework and don't have time to do everything else.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>He always explains things in a hard way.</td>
</tr>
<tr>
<td>Cara</td>
<td>Year six</td>
<td>-</td>
</tr>
<tr>
<td>Cara</td>
<td>Year seven</td>
<td>Cause it is boring.</td>
</tr>
<tr>
<td>Leigh</td>
<td>Year six</td>
<td>Cause it is boring.</td>
</tr>
<tr>
<td>Leigh</td>
<td>Year seven</td>
<td>Cause it is more fun to just to be doing stuff instead of writing stuff down like we do every day.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>It's boring</td>
</tr>
<tr>
<td>Tatiana</td>
<td>Year six</td>
<td>-</td>
</tr>
<tr>
<td>Tatiana</td>
<td>Year seven</td>
<td>Because I get bored doing it.</td>
</tr>
<tr>
<td>Anne</td>
<td>Year six</td>
<td>Every time I write in my book I have to redo it because I misspell something.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Because there are always big words and it “herts” my wrist</td>
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<td></td>
<td></td>
<td>I just don't like cleaning up after it.</td>
</tr>
</tbody>
</table>
6. Ideas of what you would do if you were in charge of planning science (focus group)?

<table>
<thead>
<tr>
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<tbody>
<tr>
<td>Belinda</td>
<td>Year six</td>
<td>If you had to explain something, you would probably most likely do an experiment because it is a lot funner. If something is fun you will remember easier. Topics – things you would most likely use the most to everyday life (relevant to life) like different things in science.</td>
</tr>
<tr>
<td>Belinda</td>
<td>Year seven</td>
<td>I would do a lot of prac's and not much writing down otherwise reading if you had to do something Focus: (agreed with Cara that you would do experiments everyday except one). I would have like you have to write out your experiments. Not like writing up experiments but I would show them what it is like if you can’t show it by doing experiments show it by doing something.</td>
</tr>
<tr>
<td>Tia</td>
<td>Year six</td>
<td>(It’s a lot funner) if you see it.</td>
</tr>
<tr>
<td>Tia</td>
<td>Year seven</td>
<td>Experiments, Lot’s of fun experiments and that (focus). Just write down a few things and then if you need to write down some more have like experiments in between so it doesn’t feel like you are writing. Watch lot’s of videos (as a substitute for writing).</td>
</tr>
<tr>
<td>Cara</td>
<td>Year six</td>
<td>Because you would do what you are doing (slime and egg in a bottle) because we are having fun while learning about stuff and if you try and explain something to someone you need them to be having fun while they are learning. If the teacher was explaining something and had gooey stuff or experiments or something with that if he had that out the front and he started explaining stuff to us we would be keeping an eye on that. (instead of drawing and writing while he is talking, said previously). Like when we have that we are paying attention. You would have fun things. You could give them the experiment and after when you are just talking about stuff or you have finished you might give them an experiment to do after you have done it. (learning things in everyday life – said by another student) agreed - Cara.</td>
</tr>
<tr>
<td>Cara</td>
<td>Year seven</td>
<td>Make experiments every day and the people in the classroom can talk. But when you are writing off the board and stuff you can talk to your friends and stuff, but you’ve got to listen to the teacher when they are talking. I would do everyday of experiments except for Wednesday which is theory.</td>
</tr>
<tr>
<td>Leigh</td>
<td>Year six</td>
<td>Why don’t they just show you an experiment and have to make you figure it out for yourself? If you see it you understand it more. If they are having fun they will pay attention more. Every science lesson I would have at least one experiment. (What sort of topics would you like? Another student answered things you would most likely use the most) as in like everyday life.</td>
</tr>
<tr>
<td>Student</td>
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<td>Response</td>
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<td>---------</td>
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</tr>
<tr>
<td>Leigh</td>
<td>Year seven</td>
<td>Probably get out all the fun stuff that we can play around with and have a break. Oh you have these rods that you rub and you get static electricity stuck on it and you can make your own or peoples hair or next to taps and all the water goes shoom. Probably get all the cool stuff out and let the kids play around with it. Well static balls and Bunsen burners and stuff. They’re fun. (If you don’t know what is going to happen in an experiment) and so if you are like ‘Ooh what’s going to happen, let’s watch closely and pay attention.</td>
</tr>
<tr>
<td>Alana</td>
<td>Year 6</td>
<td>-</td>
</tr>
<tr>
<td>Alana</td>
<td>Year seven</td>
<td>I’d probably do a lot more experiments but I would take it a lot slower so you can finish what you are learning before having to start something else so you can remember that thing as well and I would make it fun. I guess by asking other people questions and making some that they understand more than just continuing on with other things. (Focus) Prac; yeh like memory games yeh (to help learn theory); how about memory cards; yeh like; if we get a project and we look it up on the internet. (would you like to do more research?) yes. I thought maybe that we should go a lot slower than you do. I liked the mixtures and the living things. I think the teachers can make a bit more of an effort they usually try and make it fun. (Charlotte: I would rather be in Primary School doing science than high school) same. The topics were easier to understand (in primary school).</td>
</tr>
<tr>
<td>Tatiana</td>
<td>Year six</td>
<td>I would get something that would explode, I would do the volcano experiment, you know how you put bicarb in a volcano.</td>
</tr>
<tr>
<td>Tatiana</td>
<td>Year seven</td>
<td>Lots of experiments and hands on stuff. (Focus) yeh like games or something to make the stuff explained better. Sheets photocopied (so as to avoid too much writing). I’d prefer that (research) to class work. They should explain it better. Like an experiment with something interesting that happens not how you have to observe something happening.</td>
</tr>
<tr>
<td>Anne</td>
<td>Year six</td>
<td>I’d do like gravity, I’d like to learn more on like space, like electrical things, magnets, (another way to record information than just writing) - draw a diagram.</td>
</tr>
</tbody>
</table>
### Appendices

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<td>Anne</td>
<td>Year seven</td>
<td>We are doing that at the moment umm, I probably would explain it more so people could understand it instead of using really large words and telling the students to go find it, that is what our teacher does and try and explain it properly. Explain it so you can understand it instead of using scientific terms and you have to try and look up the scientific term. (Instead of writing) record it. You can find out a lot more with your own research. Find out what happened (yourself in experiments)</td>
</tr>
<tr>
<td>Belinda</td>
<td>Year six</td>
<td>-</td>
</tr>
<tr>
<td>Belinda</td>
<td>Year seven</td>
<td>Like she might tell us between these pages and these pages but we have got to find them and we have got to summarise and then we have got to write, and then we get into trouble if we don’t summarise or write.</td>
</tr>
<tr>
<td>Tia</td>
<td>Year six</td>
<td>If not you always fall asleep in the lessons. (If you don’t do practical).</td>
</tr>
<tr>
<td>Tia</td>
<td>Year seven</td>
<td>I wouldn’t do too much writing.</td>
</tr>
<tr>
<td>Cara</td>
<td>Year seven</td>
<td>Not as much writing on the board and stuff</td>
</tr>
<tr>
<td>Leigh</td>
<td>Year six</td>
<td>(When the teacher talks and people sit there and draw and stuff – another student) cause it is really boring.</td>
</tr>
<tr>
<td>Leigh</td>
<td>Year seven</td>
<td>-</td>
</tr>
<tr>
<td>Alana</td>
<td>Year six</td>
<td>-</td>
</tr>
<tr>
<td>Alana</td>
<td>Year seven</td>
<td></td>
</tr>
<tr>
<td>Tatiana</td>
<td>Year six</td>
<td>Not as much reading.</td>
</tr>
<tr>
<td>Tatiana</td>
<td>Year seven</td>
<td>-</td>
</tr>
<tr>
<td>Anne</td>
<td>Year six</td>
<td>-</td>
</tr>
<tr>
<td>Anne</td>
<td>Year seven</td>
<td>Well I wouldn’t write five pages worth of writing on the board. Because we are having to continually copy cause our teacher writes really fast and if we don’t keep up we have to copy off someone else. (Go slower) the teacher is rushing us because we are behind.</td>
</tr>
<tr>
<td>Belinda</td>
<td>Year six</td>
<td>Science and Maths.</td>
</tr>
<tr>
<td>Belinda</td>
<td>Year seven</td>
<td>Probably maths and science when we do prac.</td>
</tr>
<tr>
<td>Tia</td>
<td>Year six</td>
<td>English, Science and art.</td>
</tr>
<tr>
<td>Tia</td>
<td>Year seven</td>
<td>Art, probably industrial arts and science and English.</td>
</tr>
<tr>
<td>Cara</td>
<td>Year six</td>
<td>English and Science</td>
</tr>
<tr>
<td>Cara</td>
<td>Year seven</td>
<td>Probably metal tech and wood tech and stuff, all my doubles, they are art, cooking, except I have gone into cooking this half of the year, I didn’t like sewing and I do wood tech now and I have got PE and that is about all and I like sport.</td>
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### 8. Favourite things at school (interview)

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<td>Year six</td>
<td>Science and Maths.</td>
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<td>Belinda</td>
<td>Year seven</td>
<td>Probably maths and science when we do prac.</td>
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<td>Year six</td>
<td>English, Science and art.</td>
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<td>Year seven</td>
<td>Art, probably industrial arts and science and English.</td>
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<td>Cara</td>
<td>Year six</td>
<td>English and Science</td>
</tr>
<tr>
<td>Cara</td>
<td>Year seven</td>
<td>Probably metal tech and wood tech and stuff, all my doubles, they are art, cooking, except I have gone into cooking this half of the year, I didn’t like sewing and I do wood tech now and I have got PE and that is about all and I like sport.</td>
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Appendices

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<tbody>
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<td>Leigh</td>
<td>Year six</td>
<td>English and Art</td>
</tr>
<tr>
<td>Leigh</td>
<td>Year seven</td>
<td>Probably cooking, woodwork, science is alright except it is not that fun, maths is pretty good and yes that will about do it.</td>
</tr>
<tr>
<td>Alana</td>
<td>Year six</td>
<td>English and writing stories, I like it when we do subjects and things like science and technology.</td>
</tr>
<tr>
<td>Alana</td>
<td>Year seven</td>
<td>Wood tech and English and PE.</td>
</tr>
<tr>
<td>Tatiana</td>
<td>Year six</td>
<td>Music, English and drama.</td>
</tr>
<tr>
<td>Tatiana</td>
<td>Year seven</td>
<td>Music, language and that’s about it.</td>
</tr>
<tr>
<td>Anne</td>
<td>Year six</td>
<td>Maths, poetry, science and tech.</td>
</tr>
<tr>
<td>Anne</td>
<td>Year seven</td>
<td>Well at the moment maths, science and English.</td>
</tr>
<tr>
<td>Belinda</td>
<td>Year six</td>
<td>Because most things will eventually lead up to doing different things in science.</td>
</tr>
<tr>
<td>Belinda</td>
<td>Year seven</td>
<td>So we to learn about stuff around us in the world, like everything has got to do with science.</td>
</tr>
<tr>
<td>Tia</td>
<td>Year six</td>
<td>It is good for us to learn and its about all different subjects, and there are lots of different kinds of science so and nearly a lot of jobs we are going to have to need to know this stuff.</td>
</tr>
<tr>
<td>Tia</td>
<td>Year seven</td>
<td>Well it helps with almost every job you have like if you want to be a doctor you need to learn about mixing chemicals and next year we have to cut up like body parts or something I think my brother said, so we would need to learn that if you want to be a doctor or a vet. Yeah, (and if you weren’t working in science) cause you learn about lots of things you learn about plants and cells and stuff and lots of things.</td>
</tr>
<tr>
<td>Cara</td>
<td>Year six</td>
<td>About how you learn about things, about where you live and stuff and about other countries. Yeh and about animals, yeh that’s about it.</td>
</tr>
<tr>
<td>Cara</td>
<td>Year seven</td>
<td>Because it helps you and if you are trying to get a job and it helps you when you are trying to do things in Uni and everything. Like if you are doing something and you have to look something up about something, you don’t have to look everything up, you pretty much already know about it, like some people that don’t go to school don’t know as much stuff. (if you didn’t do science at school) you wouldn’t know as much, you couldn’t be able to specify things and that like animals and everything. We are doing dichotomous keys so you can figure out what sort of things.</td>
</tr>
<tr>
<td>Leigh</td>
<td>Year six</td>
<td>I don’t know. Well it depends if you are going to be someone who works with scientific things or not. (Teacher what if you were not going to work in science) I don’t know, you may still want to learn about science in case you had to do something with it.</td>
</tr>
</tbody>
</table>
## Appendices

<table>
<thead>
<tr>
<th>Student</th>
<th>Year</th>
<th>Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>Leigh</td>
<td>Year seven</td>
<td>So that you know how stuff works and what you should play with, and what you shouldn't, what you can play with and what you shouldn't do. So you don't play with dangerous substances and injure yourself.</td>
</tr>
<tr>
<td>Alana</td>
<td>Year six</td>
<td>I think it is fantastic because science helps people live and creates new things like spaceships and people can go into space. I think it's good that we can learn about these things and how people have put all their hard work into these things so we can learn about them, so I think that's cool. Its practically all around you science, everywhere you go there is a mixture of science everywhere.</td>
</tr>
<tr>
<td>Alana</td>
<td>Year seven</td>
<td>It is practically the main subject because everything is practically science and I guess you need to learn it.</td>
</tr>
<tr>
<td>Tatiana</td>
<td>Year six</td>
<td>To learn about how things work and what is happening like around us.</td>
</tr>
<tr>
<td>Tatiana</td>
<td>Year seven</td>
<td>Because science is in everyday life a lot and if you want to become like a doctor or something you need to know science and that.</td>
</tr>
<tr>
<td>Anne</td>
<td>Year six</td>
<td>I reckon it's because they want us to find out everything we can during school, so there is something to fill the gaps between maths and English.</td>
</tr>
<tr>
<td>Anne</td>
<td>Year seven</td>
<td>(If you didn't do science at school) then we wouldn't be able to figure out heaps of stuff, like the different kinds of plants and animals and the stuff on how to actually find out which is which, and we wouldn't be able to do stuff like cooking and stuff. (it helps you with) Just about everything</td>
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## 10. What do you want to do when you leave school?

<table>
<thead>
<tr>
<th>Student</th>
<th>Year</th>
<th>Response</th>
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<tbody>
<tr>
<td>Belinda</td>
<td>Year seven</td>
<td>Be an accountant or a lawyer.</td>
</tr>
<tr>
<td>Belinda</td>
<td>Year seven</td>
<td>I am not sure, probably go to university, maybe a lawyer or an accountant.</td>
</tr>
<tr>
<td>Tia</td>
<td>Year six</td>
<td>I want to work with animals when I am older.</td>
</tr>
<tr>
<td>Tia</td>
<td>Year seven</td>
<td>Be a vet</td>
</tr>
<tr>
<td>Cara</td>
<td>Year six</td>
<td>I want to find a cure for cancer.</td>
</tr>
<tr>
<td>Cara</td>
<td>Year seven</td>
<td>I still want to find a cure for cancer</td>
</tr>
<tr>
<td>Leigh</td>
<td>Year six</td>
<td>I would like to breed horses and dogs.</td>
</tr>
<tr>
<td>Leigh</td>
<td>Year seven</td>
<td>No, I don't really know what I want to do. I will have figured out by year ten when I take my electives.</td>
</tr>
<tr>
<td>Alana</td>
<td>Year six</td>
<td>Well I want to be some kind of farmer.</td>
</tr>
<tr>
<td>Alana</td>
<td>Year seven</td>
<td>I used to want to be a farmer and I still kind of do, but I have changed my mind a bit but I would like to maybe be an actor cause I go to drama school and I find that it is really fun.</td>
</tr>
<tr>
<td>Tatiana</td>
<td>Year six</td>
<td>I first thought about being a vet, then I thought about being a doctor, then a lawyer and a teacher.</td>
</tr>
<tr>
<td>Tatiana</td>
<td>Year seven</td>
<td>I was thinking of being a lawyer and I was sort of thinking of doing something with animals or something to do with music.</td>
</tr>
<tr>
<td>Student</td>
<td>Year</td>
<td>Response</td>
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<tr>
<td>---------</td>
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</tr>
<tr>
<td>Anne</td>
<td>Year six</td>
<td>I have wanted to be a surgeon from when I was very young.</td>
</tr>
<tr>
<td>Anne</td>
<td>Year seven</td>
<td>I would like to travel the world, child care like preschool and nannying and stuff.</td>
</tr>
<tr>
<td>11. How Would you compare Primary School and High School Science? Belinda</td>
<td>Year seven</td>
<td>in primary you got like a whole heap of notes and stuff and weren’t research it ourselves like here we will get notes and stuff and write down and do it in prac and then we will sometimes we will research it ourselves and mostly we do it all in class. Well in primary we had to do it at home (research) which is kind of annoying but here we get to do it during class and stuff and we get more done because we don’t get distracted as easily.</td>
</tr>
<tr>
<td>Tia</td>
<td>Year seven</td>
<td>Well it is a lot different because at primary school we just wrote stuff off the board, we didn’t really do very much and now we sort of learn about lots of different subjects like a bit more and we can do experiments and stuff on them and we get to use equipment like Bunsen burners and all that sort of stuff, and beakers and we didn’t have any of that in primary school. (focus) Well we didn’t do much experiments. Just once a week we wrote down a whole page of stuff and we did a little project on it.</td>
</tr>
<tr>
<td>Cara</td>
<td>Year 7</td>
<td>(in Primary school) The teacher just wrote stuff up on the board and we had to copy it down. Like we got the information and stuff and we figured out what we had to do and then we just had to go home and do that and we didn’t have like really hard topics or anything. (In high school) we have to use books and computer and stuff but at other school we could use books but he mostly liked computer stuff because that is where he got his information from. The teacher expects a lot more from you in High School. (Focus) One thing I liked about primary school is you would do your science +experiments and if it is not what the teacher expects if it is not as good as what they want they don’t really care, like they will care they will just ask each other, but here if you do a really bad job you will get into trouble, not me of course.</td>
</tr>
<tr>
<td>Leigh</td>
<td>Year seven</td>
<td>It's really boring in Primary School (science). Because you actually never did much experimentation its all like writing it down and being told what would happen. It is a lot better and you learn a lot more (in high school). Because you can actually see what is happening and you don’t just get told it. We didn’t do very much at all (Primary Schools). I don’t think primary schools are allowed Bunsen burners or anything. (Focus) Boring (Primary Science). (Compared to Primary School high school science is) excellent.</td>
</tr>
<tr>
<td>Alana</td>
<td>Year seven</td>
<td>I think that now that I know there so much more doing science and that I think with Primary school it was just like learning the basics. Like ABC and the alphabet and now I thing it is a lot funner in high school because you find out that there is so many more things to learn and in primary school you just do the basics.</td>
</tr>
</tbody>
</table>
11. How would you compare Primary School and High School Science?

<table>
<thead>
<tr>
<th>Student</th>
<th>Year</th>
<th>Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tatitana</td>
<td>Year seven</td>
<td>I preferred science in primary school. Cause when we did science, like when we made a volcano and when we did the rocks and that we actually did a test and that with and it was more hands on and that. There are a lot more assignments (in high school). Sometimes I think like we sort of did more experiments because we didn't do much science but when we did we did more experiments (in primary). The topics were probably a lot funner than here.</td>
</tr>
<tr>
<td>Anne</td>
<td>Year seven</td>
<td>Well they are a lot more interesting than the primary school ones. Cause, like in Primary School the teacher didn’t do much science, it was only once every three weeks if we had time. It is a lot more interesting because we have more stuff to do. It is a lot more interesting here (High school) because you work with the gas and Bunsen burners. (Focus) : I like it better in high school it is more interesting. There was a lot more to do. Usually in Primary School its like does it sink or float, go and do that, but in high school you have to try and figure out, figure it out properly.</td>
</tr>
</tbody>
</table>
APPENDIX G

Summaries of Student Responses from Data Sources Such as Individual Interviews, Focus Groups, Short Survey Questions, and Open Responses on the Attitudinal Survey; These Responses have been Grouped According to Gender, Ability and Class

*Attitudes and Interest in Science – Year six Primary School, Year seven High School Summary of Male, High Ability Combined Responses total (5)*

<table>
<thead>
<tr>
<th>Question</th>
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<th>Frequency</th>
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<th>Year</th>
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<td>What do you like about science?</td>
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<td>“</td>
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<td>5/5</td>
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<td>“</td>
<td>7L</td>
<td>3</td>
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<td>“</td>
<td>7K</td>
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<td>5/5</td>
<td>7</td>
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<td>Making Things</td>
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<td>Diagrams</td>
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<td>Explosions</td>
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<td></td>
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<tr>
<td>Bunsens / fire</td>
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<td>Circuits</td>
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<td>About human life/animal science</td>
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<td>1/5</td>
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<td>Discover things to improve life</td>
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<td>Field trips</td>
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<td>Why do you like it?</td>
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<td>They are cool</td>
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<td>I like looking at things instead of being told or watching the teacher</td>
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<td>demonstrate</td>
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<td>Increases knowledge</td>
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<td>Because you don’t have to write much</td>
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<td>Because things explode</td>
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<td>For your occupations</td>
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<td>More student centred experiments where students discover what happens</td>
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<td>Do experiments outside</td>
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<td>3/5</td>
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<td>Why do we do science at school?</td>
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<td>1/5</td>
<td>6</td>
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<td></td>
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<td>7L</td>
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<td>2</td>
<td>4/5</td>
<td>7</td>
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<td>6H</td>
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<td></td>
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<td>3</td>
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<td>7K</td>
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APPENDIX H

Narratives: Schools, Classes and Teaching Style

These narratives have been compiled using data from classroom observations, student and teacher interviews, focus groups, students’ work samples, student journals, researcher diary entries, short survey responses and open responses on the attitudinal questionnaire. The narratives are intended to give the reader a general picture of each school and classroom environment, and the teaching style of the teachers represented in the study. Names of all participant schools, classes and teachers have been replaced by pseudonyms for privacy. The narratives were written in present tense as the primary narratives were written in 2004 when the participant students were in year six and the secondary narratives were written in 2005 when the students were in year seven.

Tuckeroo Primary School (school A in attitudinal survey)

Tuckeroo Primary School is a large school in a village in regional NSW. There are students from two classes at Tuckeroo Primary School who are participants in the study. These classes are outlined in the following section.

6H

Class one (6H) from Tuckeroo Primary School, is an opportunity class that has been set up for students in the region who are intellectually gifted. The opportunity class is a composite year five/six class. The study includes eight students from this opportunity class, four boys and four girls. The teacher, Mr Beck, presents science regularly. The students are encouraged to research extensively using computer sources and they often carry out their own investigations, usually as homework. In addition to their research, theory based science is presented in the classroom that includes a large amount of copying of notes and the students’ science books reveal extensive written work (both from their own research work and from copying notes from the board). Some of the participant students have mentioned in interviews and focus groups how Mr Beck gives comprehensive teacher explanation about science concepts and it appeared that some of the participant students appeared disinterested during this time. During the observation of science lessons, Mr Beck allowed general discussion and the students viewed videos of various science topics. Mr Beck explained that as a result of time restraints and lack of...
science equipment, practical science was not presented very often. However, the class was observed while a pre-service teacher provided the students with a practical activity using electrical circuit equipment. The participant students were motivated and engaged during this activity and manipulated the equipment confidently.

6R

Class two (6R) in the study is year six, with one female student who is a participant in the study (a male student participant moved interstate before the study commenced). The class experienced a number of changes of teaching staff, including a number of casual teachers. A permanent teacher, Mrs Hutchinson, took over the class mid year. Mrs Hutchinson explained that very little science had been presented prior to her appointment. She said that the class required direction with practical science and she is gradually introducing more student-centred science and encouraging the students to carry out investigations. Mrs Hutchinson stated that Science often is postponed as a result of other activities that disrupt the ordinary class programme. I observed the students carrying out investigations (where the students designed and carried out activities independently, made hypotheses and investigated to seek answers). The students took part in research with the use of computers, and I observed them working collaboratively in groups to make note of where erosion occurred in the school grounds. The students also took part in investigations where they designed fair tests, for example exploring micro-organisms such as mould on food.

Hillside Primary School (school B in attitudinal survey)

6S

Only one class is represented in the study at Hillside Primary School. It is a medium sized school in residential village in regional NSW. Six students from Hillside Primary School are participants in the study, three girls and three boys from a year five/six composite class (6S). The teacher, M/s Pryor, is the co-ordinator of science in Hillside Primary School. M/s Pryor presents student centred, practical science and endeavours to keep ‘writing’ to a minimum. M/s Pryor encourages the children to develop their science skills and provides experiences for the children to build on their conceptual knowledge in science by eliciting the children’s prior knowledge and planning accordingly. She would like to teach more
science but she said she is prevented from this as a result of a crowded curriculum. The
students were observed participating in a ‘design and make’ activity, where they
constructed instruments to measure weather conditions. A practical lesson was observed
where the students identified rocks using fair testing. The students were encouraged to
present their artefacts or results of observations, of all practicals, to the class and to discuss
what they had discovered during the topics.

One Tree Primary School (not included in original attitudinal survey, 2004)
6T

One Tree Primary School is a small rural school in regional NSW and only one class from
the school is represented in this study. There are six student participants from One Tree
Primary School, three girls and three boys. The original teacher of the composite year
five/six class (6T) was transferred to another school at the end of term one. A number of
casual teachers were employed to teach year five/six prior to the appointment of a
permanent teacher, Mr MacPherson, who said science was neglected prior to his arrival at
the school. Mr MacPherson, has a strong science background and had previously been
employed as a specialist primary teacher for a number of years. He has been providing the
students with opportunities to develop their science skills. The science lessons observed
were ‘hands on’ and encouraged the students to ‘problem solve’. The students worked in
science activities in the classroom during my observations carrying out fair testing and
manipulating science equipment. The students also took part in science exploration
activities in the school grounds such as observing plant structure and collecting specimens
of seeds and fruits. One of the participant students from One Tree Primary School although
starting at Meadows Secondary School, left the school early in first term so she did not
participate in the study in year seven.

Meadows Secondary School (school C in attitudinal survey)

Meadows Secondary School is situated in a village in regional NSW. When the student
participants in the case study commenced at the secondary school they were distributed
into each of the six, year seven classes. The two high ability classes and four mixed ability
classes are described in the next section.
In Mr Lyons’s class (7L), a high ability class, the students take part in a large number of practical activities, these are teacher directed but the students are often given the opportunity to explore during these practical classes. The students, workbooks from these classes indicated that they did not have as much writing as some of the other science classes and they were given photocopied sheets of notes to paste into their books. All students appeared generally motivated and engaged during the observations of this class both in practical lessons and theory lessons with the exception of one student, Tyson who is discussed below (Appendix I).

Mrs White’s class is a high ability class. She had been teaching for only three years (approximately) and had started her teaching career at Meadow’s Secondary School. In Mrs White’s class (7K) the students participated in a number of practical lessons, but there appeared to be a large amount of theory lessons with excessive copying of notes. Not all participant students were focussed during class discussions and theory lessons but they appeared very interested and engaged during the practical activities. The biology topics seemed to be largely theory based. Mrs White was particularly keen for the students to be accurate with their scientific drawings and she encouraged them to use rulers for these tasks. She used sarcasm in her conversations with the students as a form of humour but this sort of discussion often resulted in the students appearing to feel humiliated by her comments that were uttered in ‘jest’. The students in Mrs White’s class complained about her high expectations, how they were rushed through topics and how much they disliked copying notes and summarising from the textbook. Mrs White discussed how it was difficult to cover all the content in science and that she believed that note taking was an efficient way for students to learn the content.

The other four classes in year seven were mixed ability classes. Mr Ryan’s class (7R) appears to have a large number of practical lessons that are organised by the teacher but where the students have the opportunity to explore with the activities. There doesn’t appear to be an excessive amount of note taking and the participant students appeared focussed
during the theory lessons. The participant student in Mr Ryan’s class appeared motivated and engaged during the practical and theory lessons.

7S

Mr Stokes presents a large number of practical lessons and there does not seem to be an excessive amount of notes taken in his class (7S). He provides the students with photocopied notes. There were some students in the class that displayed behavioural problems and were distracted during theory lessons, although the participant students always appeared focussed and engaged, particularly during practical lessons. The students participant students appeared generally positive towards their science lessons in this class.

7H

Mr Lee’s class (7H) consisted of a large number of students with behavioural problems, including the two participant students. Mr Lee would spend most of the lesson talking and providing notes on the board for students to copy. Any practical lessons would be left to the final ten minutes (approximately) of the lesson, consequently the students were rushed and the rarely finished their tasks. The participant students were distracted during theory lessons and displayed ‘off-task’ behaviour such as throwing objects and teasing the students around them, but they both appeared to enjoy the practical lessons.

7P

Mr Davidson’s class (7P) was a low ability class where most students were diagnosed with learning difficulties and behavioural problems. Mr Davidson gave the students opportunities to take part in practical lessons when there was supervision from a teacher’s aide and an additional teacher. The students appeared to enjoy the practical lessons, Charlotte was often distracted during science lessons generally but Matt was mostly focussed during theory and practical lessons when I observed him. The students were given the opportunity to explore during the practical lessons that were essentially teacher directed. Note taking was kept to a minimum and students were given photocopied notes.
APPENDIX I

Narratives: Student Participants

These narratives have been compiled using data from student and teacher interviews, focus groups, classroom observations, students’ work samples, student journals, researcher diary entries, short survey responses and open responses on the attitudinal questionnaire. The narratives are intended to give the reader a general picture of each case study participant student’s general interests and attitudes, particularly related to science. Names of all participant students, schools, classes and teachers have been replaced by pseudonyms for privacy. It is hoped that the narratives describing both the classroom and school environment (Appendix H) and those describing each student while in year six and year seven, will give the reader a glimpse into how each student perceived his or her school science experience at the time these narratives were written.

Narrative for Alana:

Alana: Year six, Primary School, 2004 (6S)

Alana is from Hillside Primary School where she is in year six in Mrs Pryor’s class. Alana loves to work outside on her farm with her Dad and also enjoys playing with her dog; she said, “it makes you feel fresher being outside”. Alana’s favourite subject at school is English, as she loves to write stories. During an interview Alana described how she loves science; “I like how the planets were discovered out of nowhere, and all the stars and how far away they are. I think I love everything about science. I loved doing the subject on soil because it’s so interesting by what it can form, as I love anything to do with farming and agriculture. I think it is fantastic because science helps people live and creates new things like spaceships and people can go into space. I think it’s good that we can learn about these things and how people have put all their hard work into these things so we can learn about them, so I think that’s cool. It’s practically all around you science, everywhere you go there is a mixture of science everywhere. It’s like people have done it for so many years and its just interesting that school kids can learn about it too”. There are some
aspects of science that she finds difficult. Alana said, “sometimes there are very scientific words that I don’t understand”. Alana scored 63 for ‘Science interest’ and the average score for year six was 58. When I observed Alana in class she appeared very interested and engaged in the science activities she was doing at school. She enjoyed identifying rocks and systematically recording their features. During a practical lesson concerned with the weather topic, Alana was enthusiastically making weather instruments with her friends. It appears that Alana has a ‘personal interest’ in science. Alana’s teacher Mrs Hutchinson, described Alana as being a “creative thinker” and a “quite achiever”. Alana’s parents completed a survey and one parent liked science at school and thought it should be compulsory for all ages. Alana’s other parent said science was not his/her favourite subject and should be compulsory only until year eight at secondary school. When Alana leaves school she wants to be “some kind of farmer”.

**Alana: Year Seven, Secondary School, 2005 (7K)**

Alana is in year seven at Meadows Secondary School. Although in primary school she was in a mixed ability class Alana is in now in Mrs White’s class, which is one of the two equal high ability classes. When Alana is not at school she likes to play sport, read, play with her dog and see her friends. Alana told me that although she enjoys working with her father on the farm, she does not have enough time now she is in secondary school as her time is taken up with homework and social commitments. Her favourite subjects in year seven are wood technology, English and PDHPE (Physical Development and Health Education). Alana likes science because “it’s discovering that the world is full of so many things, I have never seen or heard of before” she said. Alana enjoys experiments in science, such as using magnets and burning magnesium. However, she told me that she had done more experiments earlier in the year. Alana said that “you learn more by actually doing it (experiments) instead of just writing or reading and it is a lot funner”. Alana finds “learning a lot of terms” in science “confusing” she said. She does not like large amounts of writing and she finds it difficult to keep up with the writing. Alana discussed how she is finding understanding some of the concepts in science, increasingly difficult. “It is hard to process them in my brain all at once”, she said. When discussing the relevance of science in school Alana stated, “science is the main subject because everything is practically science and I guess you need to learn it”. In response to a question relating to planning her
own science lessons, Alana said, “I would probably do a lot more experiments and I would make it fun. I would take it a lot slower so you can finish what you are learning before having to start something else, so you can remember that thing”. Alana went on to say that she would organise more questions with the class, to help the students understand the topic. She would also use memory cards and organise more research with the use of the Internet. While taking part in a practical science lesson, Alana appeared interested, she listened to the teacher’s instructions and set up and packed away her equipment efficiently. During a theory lesson, Alana was distracted and did not seem to pay attention. Mrs White asked Alana a question towards the end of the lesson and she seemed confused and was unable to give the teacher an answer. Alana’s book is carefully detailed and neat. Her scientific drawings appeared clear and well detailed, but there was a note from the teacher stating that her drawings were “crooked and too small”. Alana received 18/20 for her book initially and 19/20 later in the year. Mrs White said that Alana is “a conscientious student who has achieved very well across all outcomes for the year. She is up there in the top third. Alana contributes when asked but never puts herself forward. She seems to like science and her attitude seems to be stable. She does not bubble over with enthusiasm for science but that could reflect her personality, because she is calm person”. During an individual interview, when asked to compare primary and secondary science Alana said, “I think with primary school it was just like learning the basics, like ABC and the alphabet. I think science is a lot ‘funner’ in secondary school because you find out that there is so many more things to learn”. Later in term three during a focus group with her peers Alana stated that she found the topics easier to understand in primary school. Alana agreed with her peers that in primary school the practical lessons were more student-centred whereas in secondary school they are teacher centred. When Charlotte stated that “science was better in primary school”, Alana responded by saying, “same”. Alana achieved a ‘Science interest’ score of 63 in an attitudinal science survey, administered in year six. Alana’s ‘Science interest’ score for the same attitudinal survey completed in year seven was 59, which was higher than the mean score of 53 for year seven students at Meadows Secondary School (this mean score did not include the 20 participant’s students’ interest scores).

Alana appeared to have mixed feelings about secondary school science. She was highly interested in, and had a very positive attitude towards, science in primary school and
Appendices

appeared to have a ‘personal interest’ in science. Alana has maintained an interest towards science in secondary school. However Alana would like to see more experiments and less writing in her science classes and she struggles with some of the scientific conceptual information. Alana particularly enjoyed the independent investigating in primary school and would like to take part in more research tasks in secondary school. Overall Alana appears to have lost some of her passion towards the subject in secondary school. When asked what sort of career she would like to follow when she finishes school Alana responded by saying “I used to want to be a farmer and I still kind of do, but I have changed my mind a bit and I would like to maybe be an actor because I go to drama school and I find that it is really fun”.

**Narrative for Alec**

*Alec: Year six, Primary School, 2004 (6H)*

Alec is a high ability year six Student, in Mr Beck’s Opportunity Class at Tuckeroo Primary School. Alec likes crabbing, fishing and playing video games when he is not at school, and he loves to spend time with his friends and neighbours. In science Alec likes doing experiments, finding out new things and researching. He likes increasing his knowledge and he enjoys experiments because “they are fun”. Alec said, “the more you know the better, the more easier it is to do things in a way. It depends on what you are really doing but sometimes it helps to know”. Alec said sometimes he finds it difficult to find information when he is researching and he doesn’t like continuously “writing down stuff; endless pages of writing”. He doesn’t like writing because it makes his hand hurt, but he said “it is probably one of the best ways of getting it into your head”. Alec is not sure why you do science at school but he said it may prepare you, “and to just help you out in secondary school”. Alec said “if you were learning about the bush you could find out about plants that you could eat and stuff, so say you were trekking and you forgot to pack food, which if you were cautious won’t happen, but if you do and you get lost you know what you can eat, so it can come in handy”. If Alec organised science at the school he would plan more excursions and leave more time to write. He would like to be able to expand on what he does, “like refracting light and stuff”. He would like to learn more and get a bit of knowledge about “anything and research more parts of it”. Alec believes it is very important to learn about everything. Alec’s ‘Science interest’ score in a quantitative
attitudinal survey is 73 (maximum possible 75; the mean score is 58 for year six), the highest score amongst the participant students. Alec appeared motivated during classroom observations of science lessons. He took part in the class discussion on electricity and appeared knowledgeable about the subject. During a practical lesson on electricity, Alec and his friends discovered a number of different ways to connect a circuit and discussed how they could make the light globes shine brighter. They managed to find a large number of batteries to connect to their circuit and commented on how the light bulbs had become “black” after experimenting with multiple batteries. Alec appeared very focussed and interested in the practical science lesson. Alec recorded his science activities in a journal and stated that “simple circuits were fun, I liked making them”. He also mentioned how he “didn’t like doing water, it was boring and I didn’t learn a single thing, not even the research was fun”. In a focus group the students were discussing how they could have made the water topic more interesting. Alec mentioned how two years ago he had “done a big experiment with water like a trundle or a wheel that spins in water”. He said if you were learning about how a dam works then you could do distillation” (relating to the water topic). Alec had carefully detailed some information in his science journal about an experiment that he and Martin had undertaken to make a water based paint. Alec and Martin were most enthusiastic to demonstrate this paint to me during a school visit. In a survey, Alec’s parents, both said they liked science when they were at school, particularly practical science. One of Alec’s parents thinks that science should be compulsory for all students, but the other stated that they thought once students had developed a good general knowledge in the subject “science should not be forced on students if it is not relevant to their careers”. When Alec leaves school he wants to be a veterinarian, “I have wanted to do this since I was three,” he said. Alec appears to have a ‘personal interest’ in science.

Alec: Year seven, Secondary School, 2005 (7K)

Alec is now in year seven at Meadows Secondary School. Alec is in Mrs White’s class, which is one of the two equal high ability classes. When he is not at school he enjoys sport, computer games, and playing with fire. His favourite subjects in secondary school are science, music and PDHPE (personal development, health and physical education). He enjoys experiments in secondary school, particularly those that involve explosions and fire because he finds those things fun. Alec likes doing the wider variety of science topics and
the experiments in secondary school science but he would like to do more research in the subject. He also said he likes “doing animal science and organisms” in science. He particularly dislikes “lot’s of writing” as he did last year, as he finds writing boring and senseless. Alec would write notes less, organise more practical lessons and more research projects if he chose what to do in science. He cannot understand why he is required to copy out large amounts of notes when he can find them in a textbook. He said if he was planning science he would make large amounts of writing “a punishable offence”. Alec loves to do experiments at home, like making sodium bicarbonate rockets and electrical gadgets with batteries. He appeared enthusiastic and engaged while taking part in practical lessons, and listened to the teacher’s instructions prior to the activity. He did not appear to pay attention during a theory lesson I observed, as he was more interested in playing a game of paper golf with Cara who was sitting in the seat next to him. Alec’s bookwork was very untidy. He was using a maths book and his science work commenced half way through the book. His sheets were not glued in and his work did not appear to be finished. When asked to compare primary science and secondary science, Alec said how he did a large amount of independent research in science in primary school and a large amount of copying notes from the blackboard. In secondary school he said he also does a large amount of copying from the board but only a small amount of independent research and he said he would like to do more independent research in secondary school. However he said, in secondary school he does a wide variety of work and more experiments, which he enjoys. Alec achieved the highest quantitative ‘Science interest’ score of 73 in an attitudinal science survey administered in year six, suggesting he had a great interest in science. His ‘Science interest’ score in the same attitudinal survey in year seven was 61, although his score remains above the mean score for year seven non-participant students at Meadows High School this decrease in ‘Science interest’ is considered to be substantial. Alec said that he was not really sure why he does science at school but he thinks it might be “to help you out if you want to do jobs like vet science, medical and all that kind of stuff or to help you out later”. Alec still wants to become a vet when he leaves school.

Alec is still keen on science in general in year seven and the subject has remained one of his favourites. He particularly likes practical science and continues to dislike writing. However, it appears that he has not maintained his passion for the subject over the primary/secondary interface although it appears that Alec has maintained his ‘personal
interest’ in science in society. Alec’s teacher, Mrs White said that Alec started the year with an excellent attitude to science. She said how much Alec likes ‘hands on’ science and she felt that Alec would prefer more practical lessons. Mrs White said that Alec was underachieving and she felt he had “lost a bit of his interest and zest” for the subject.

**Narrative for Anne**

*Anne: Year six, Primary School, 2004 (6S)*

Anne is in year six at Hillside Primary School in Mrs Pryor’s Class. Anne likes learning lawn bowls, Japanese and reading. Her favourite subjects at school are maths, poetry and science. Anne likes to do experiments in science. She commented how she never gets bored in science and “science is just something different to everything else you learn in school. English and maths is always the same but science always changes”. Anne also likes experiments and she said, “I don’t have to write during them at all”. She doesn’t like writing in science, and she remarked how there are always big words to write and it “hurts my wrist after a while”. However, Anne said, “I do not do as much writing in science as every other thing” but her bookwork is well detailed. Other aspects of science that Anne doesn’t like are, cleaning up after experiments and having to follow strict instructions and she said how she is “hopeless at measuring”. Anne’s ‘Science interest’ score in the quantitative attitudinal survey is 70 (the mean score is 58 for year six). During a classroom observation Anne worked with her friends, carefully examining rocks and recording the results of simple tests. She was eager to take part in the discussion time and report her findings from the practical. Anne was most enthusiastic during a ‘design and make’ activity where the students worked in groups to make weather instruments. She redesigned her instrument and carefully tested it; she used problem-solving skills to adjust it and enable it to work efficiently. If Anne planned her science lessons she would do activities like looking at gravity and she would like to learn more about space, electricity and magnets. Anne said that it would be better to draw diagrams than do extensive writing. Anne believes that science is presented at school because “they want us to find out everything we can during school, so there is something to fill the gaps between maths and English”. Mrs Pryor said, “Anne is quite keen on science and likes to work on her own and investigate. Anne definitely has an interest in science”. A survey was completed by one of Anne’s parents and it was stated that he/she liked science and believes
that science should be compulsory for all ages. When Anne leaves school she wants to be a surgeon, she has wanted to follow this career from when she was very young.

**Anne: Year Seven, Secondary School, 2005 (7K)**

Anne is in year seven at Meadows Secondary School. Although in Primary School she was in a mixed ability class she is in now in Mrs White’s class, which is one of the two equal high ability classes. Anne likes reading and learning Japanese when she is not at school, as she did last year. Her favourite subjects at secondary school are maths, science and English. Anne said that she still likes doing experiments in science, and particularly experiments such as, playing with Bunsen burners and burning magnesium that she is able to do in secondary school. She said she likes experiments because “we get to do stuff instead of sitting there and writing from the board for the entire lesson”. During a focus group Anne stated “students can find out more doing their own research or find out information by doing an experiment”. However, Anne said that she finds it difficult “to be exact in experiments”. Anne enjoys learning “new things” in science and doing research tasks but she continues to dislike writing in science. She said, “our teacher writes the notes really fast and we don’t keep up”. Anne also believes that the class is “rushed” too quickly through topics in science. If Anne planned her science lessons she would explain the science concepts clearly so people could understand, and she would avoid using “really large words”, she said. Anne appeared engaged in, and motivated towards, a practical lesson that I observed. During a theory lesson Anne appeared to listen to the teacher talking and was focussed while doing her bookwork. Anne’s bookwork is comprehensive, neat and her drawings are well detailed. There is a large amount of writing in her book. Anne’s bookmark was 17/20. Mrs White believes that Anne likes science but she mentioned how Anne becomes anxious in the subject, particularly if she is disrupted from what she is doing. Mrs White said that Anne achieved very highly in the first semester but her level of achievement dropped slightly, in second semester, “probably as a result of illness”. When describing why she does science in school Anne said “science helps us figure out heaps of stuff, like the different kinds of plants and animals and how to find out which is which. It helps us with stuff like cooking. Science helps you with just about everything”. Anne achieved a very high quantitative ‘Science interest’ score of 70 in the attitudinal science survey, in year six. Anne’s ‘Science interest’ score for the same
attitudinal survey in year seven was 63, which was considerably higher than the mean score of 53 for year seven students at Meadows Secondary School (this mean score did not include the 20 participant’s students’ interest scores). When asked to compare primary school and secondary school science, Anne responded by saying “it is a lot more interesting in here (in secondary school) because we have more stuff to do like working with gas and Bunsen burners. In primary school we did not do as much science, it was like does it sink or float? Or go and do that. In secondary school, you have to figure it out, figure it out properly”.

Anne has remained interested in, and positive towards science, over the primary/secondary interface. It appears that Anne likes science in secondary school more than in primary school. However there are some aspects of year seven that Anne finds frustrating, such as the large amount of writing and rushing through the topics in science. When Anne leaves school she would like to work in “child care, like preschool, or become a nanny and travel the world” she said.

_Narrative for Belinda_

**Belinda: Year Six, Primary School, 2004 (6H)**

Belinda is a high ability year six student, in Mr Beck’s Opportunity Class at Tuckeroo Primary School. She likes playing with her friends and going to the movies when she is not at school. Belinda’s favourite subjects at school are science and maths. To describe what she likes about science Belinda said, “I like learning different things that I didn’t know about a subject, then going home and finding information and finding out more”. Belinda also likes making things in science, learning about plants, animals, the Earth, and why and how things work. Belinda said that she likes learning about these aspects of science because “its fun to learn about things I like and how they live, work or move”. Belinda believes science is important in school “because most things will eventually lead up to doing different things in science”, she said. Belinda’s ‘Science interest’ score in the quantitative attitudinal survey is 62 (the mean score is 58 for year six). During a classroom observation in science Belinda appeared to listen carefully to Mr Beck discussing electricity, but she wasn’t given the opportunity to answer some questions that he asked. She also was focussed while watching a science video. During a practical lesson Belinda
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was engaged and motivated and appeared to enjoy making an electrical circuit. If Belinda was organising science for her class and something needed to be explained, Belinda would use an experiment to explain something because “it is a lot ‘funner’ and if something is fun you will remember easier” she said. Belinda said that she would also prefer to do “things (in science) you would most likely use the most in everyday life”. Mr Beck said that Belinda loves to do science using the power point program on the computer and he believes Belinda really enjoys science. Belinda’s bookwork is extensive, very neat and well detailed. In a survey completed by Belinda’s parents, both parents said they liked science when they were at school, particularly the experiments. One parent believed that science should be compulsory for students of all ages and the other parent believed science should only be compulsory for students from years 4-12. Both parents stated that the environmental side of science should be emphasized in primary school. Belinda would like to be an accountant or a lawyer when she leaves school.

Belinda: Year Seven, Secondary School, 2005 (7K)

Belinda is now in year seven at Meadows Secondary School. She is in Mrs White’s class, which is one of the two equal high ability classes. Belinda likes to ride her bike, spend time with her friends and go shopping when she is not at school. Her favourite subjects at secondary school are maths and practical science lessons (not science theory). Belinda likes to do experiments in science as she finds them interesting. Belinda does not find anything difficult to do in science. She does not like writing constantly as she finds it “pretty boring”, she said. If Belinda planned her science lessons she would organise regular practical activities and not much writing down. She would prefer to read information than copy notes and she would use practical examples to explain scientific information. She would not ask the students to summarise information from certain sections in the textbook like the teacher sometimes does in secondary science. When asked why she thinks she studies science in school she replied “to learn about stuff around us in the world, like everything has got to do with science”. Belinda appeared engaged and motivated during my observations of her science lessons. She listened to the teacher demonstrating the practical task and appeared enthusiastic while taking part in the practical activity. She discussed the conceptual aspects of the results of the experiment she set up and she efficiently set up and packed her equipment away. Belinda appeared to be engaged
during the theory lessons I observed. However I did not observe Belinda volunteering to take part in class discussion. Mrs White said that Belinda “is very engaged and interested and gives of her best and asks questions” and that she appears “to like science and she achieves good results”. She went on to say, that Belinda “seems to understand concepts and apply them easily” and she is ranked in the top 5 in the year. Belinda was absent for a whole unit during third term in year seven as she was visiting family overseas. Mrs White said how Belinda had achieved high marks in her exam despite missing some topics and Mrs White believed this was “really commendable”. When asked to compare primary school and secondary school Belinda replied, “in primary we got a whole heap of notes and we would research it ourselves. Here (secondary school) we will get notes, do it in prac and sometimes we will research it ourselves. In primary we had to do it all at home, which is kind of annoying, but here we get to do it in class and we get more done because we don’t get distracted easily”. Belinda achieved a quantitative ‘Science interest’ score of 62 in the attitudinal science survey, in year six. Belinda’s ‘Science interest’ score for the same attitudinal survey in year seven was 53, which is equal to the mean score for year seven non-participant students at Meadows Secondary School. This decrease in ‘Science interest’ score is considered to be substantial. When evaluating Belinda’s interviews, focus groups, observations, teacher interviews and work samples, it appears that Belinda has retained an interested in practical science, but she finds some parts of the subject frustrating and boring, such as copying of notes and summarising information. Practical science classes have remained among Belinda’s favourite subjects and she would like to do more practical science tasks. Belinda said that she might go to University when she finishes school and she continues to want to pursue a career as a lawyer or an accountant.

_Narrative for Bob_

Bob: Year Six, Primary School, 2004 (6S)

Bob is in year six at Hillside Primary School in Mrs Pryor’s class. Bob said he likes to play with his dogs, watch TV, relax and “do outside things” when he is at home. Bob’s favourite subject at school is sport and he particularly likes soccer. He enjoys playing sport because he likes being outside. Bob loves ‘hands on’ activities in science and he likes doing experiments and “making stuff”. He likes practical activities, because they are fun. “You don’t have to watch someone else demonstrate”, he said. Bob said there is not much
about science that he doesn’t like apart from writing. Bob said, “I think writing is a waste of time and “I just don’t like it”. He discussed how he could avoid writing if he was organising a science lesson. Bob said, “I would get all the stuff and I would hand out a sheet for science, so when the students were finished doing their activities they could stick them into their books, or you could put head phones on and record everything”. Bob is not sure of the purpose of studying science in school. Bob’s ‘Science interest’ score in the quantitative attitudinal survey is 55 (the mean score is 58 for year six). However he appeared very motivated during the practical lessons that were observed. He brought a collection of rocks to school, from home and appeared most interested to carry out tests on them. He presented the rocks to the class and discussed them in great detail. Bob appeared very interested in a design and make activity. He meticulously built his weather instrument with his peers and enthusiastically tested it and made adjustments until it worked. Bob was very interested to discuss his practical experiences in a class discussion. Mrs Pryor said that Bob is “highly interested in science and any sort of investigation, always keen, doesn’t like the written work or the bookwork but always keen. Bob loves science and I am sure he is interested in it outside of school”. In a survey completed by Bob’s parents, one parent said he/she did not especially like school science and could not see ‘the point of it” and the other parent said that science was his/her favourite subject at school. Both Bob’s parents feel science should definitely be compulsory for all ages. Bob has no idea what career he will follow, when he leaves school.

**Bob: Year Seven, Secondary School, 2005 (7K)**

Bob is in year seven at Meadows Secondary School. Although in primary school he was in a mixed ability class, Bob is in now in Mrs White’s class, which is one of the two equal high ability classes. Bob continues to enjoy outside activities, he likes to playing soccer, play with his dogs and “have fun” when he is not at school. His favourite subjects in secondary school are wood technology and art. Bob said he likes the experiments in science “because they are cool”. He said he particularly likes experiments where he is “lighting stuff on fire and stuff that blows up”. Bob does not find anything difficult in science. He dislikes writing and he said “we do too much of that”. Bob discussed how he would present science if he were given the opportunity to plan his science lessons. He would present more practical lessons and “make them more interesting” he said. Bob
believes by doing practical tasks the students can actually see what is happening, rather
than just writing about what happens, also he would not tell the students what is likely to
happen in an experiment before they perform it. Bob would avoid writing in science and he
would “ban all the paper”, he said. However, Bob thinks that ‘print outs’ of the work for
the students would be a good idea. He would also plan more practical lessons outside in the
school grounds. Bob believes that it depends on the type of career you plan to follow or
how you look at life, as to whether studying science in school is important. During
classroom observations Bob appeared to be motivated towards, and engaged in science. He
took part in the class discussions in science theory lessons and was engaged and focussed
during practical lessons. Bob’s bookwork was a little ‘messy’. His drawings were poor and
the book was generally poorly organised. The first mark for Bob’s bookwork was 13/20
and later in the year he received a lower mark of 12/20 for his bookwork. Mrs White said
that Bob performs very well in tests and that she believes he is interested in science.
However, she said that she thinks Bob would prefer more practical classes in science. Mrs
White described how Bob is very keen to take part in class discussion and she said, “He is
interested and engaged to a point where he is actually disruptive of others as he constantly
calls out answers”. Mrs White went on to say, “to me that demonstrates an interest. There
is a balance and we have to try and achieve it with him”. Bob achieved a ‘Science interest’
score of 55 in an attitudinal science survey administered in year six. Bob completed the
same attitudinal survey in year seven and his score was 59, which was above the mean
score of 53 for year seven students at Meadows Secondary School (this mean score did not
include the 20 participant’s students’ interest scores). When asked to compare primary
school science with secondary school science, Bob responded by saying, “last year we
didn’t really do much of it (science) and now we do like 40 minutes a day”. When asked if
he thought doing science everyday was ‘ a good thing’, Bob replied by saying “no”. Bob
went on to say, “primary school was interesting then but now parts of it are more
interesting in secondary school and it is stuff that I didn’t know before”.

The slight increase in Bob’s quantitative ‘Science interest’ score together with the data
obtained from interviews, focus groups, teacher interviews and observations suggest that
Bob has maintained his interest in, and positive attitude towards, science over the
primary/secondary interface. He appears to have become slightly more positive towards
science, particularly the practical lessons. However, Bob dislikes the large amount of
writing in science and would like more student centred investigations in his practical classes. Bob continues to be unsure of the career he will follow when he finishes school.

**Narrative for Bree**

*Bree: Year Six, Primary School, 2004 (6R)*

Bree is in Mrs Hutchinson’s class at Tuckeroo Primary School. Bree likes dancing and playing soccer when she is not at school, as these activities make her feel happy and better about herself. Her favourite subjects at school are art, English and probably PE (PDHPE, Physical Development and Health Education). Bree is fascinated with ‘hands on’ science. Bree enjoys experiments in science because she is given the opportunity to perform her own investigations and she also likes researching in science. Bree said, “if you learn about things you don’t know, then they will be interesting”. Bree does not find anything difficult in science but she said, “I don’t like writing down all that stuff, particularly if you write down things you already know about because it can be boring”, she said. When I asked Bree why we do science in school, she said, “you wouldn’t know about things, you wouldn’t know about what the Earth is all about and what you are all about, you wouldn’t know much because it affects our future and what our jobs are”. If Bree planned her science lessons, she said, “I would make slime or make disgusting things and make it more fun. It would not be just finding out information and writing it down; it would be ‘hands on things’, like discovering about things you don’t know”. During a focus group session with Bree and two of her peers, Bree suggested an alternative to large amounts of writing in science, “We could make a video, like a diary of each day of what happens and just say what day it is or you could get a digital camera and take photos of each day and stick them into a book”, she said. Bree would like science concepts explained by someone older, “who really knows what they are talking about”, she said. Bree’s ‘Science interest’ score in a quantitative attitudinal survey is 61 (the mean score is 58 for year six). Bree appeared to be very excited and motivated when carrying out an investigation designed by her and her peers, looking at food and mould. Bree appeared quietly confident when taking part in a class discussion concerning erosion. During a group work session in the school grounds, it appeared that Bree’s peers relied on her for direction. She initiated the ideas when carrying out the observation and discussed with her peers information to report back to the class at the end of the practical. During a research lesson Bree was focussed and
worked steadily with a peer to search the Internet for information on erosion. The students were asked to create a story about a grain of sand after their research session. Bree appeared embarrassed when Mrs Hutchinson asked her to read her story in front of the class. There was little information in Bree’s science book as science was presented very rarely in Bree’s class. The class had been lead by a number of different teachers during year six. Mrs Hutchinson said that Bree does not initiate experiments or further research in science, “but she does what she has to do with full enthusiasm”. In a survey completed by Bree’s parents, both parents stated that they liked science at school. Bree’s mother stated that she enjoyed learning about the environment and biology. Her father said physics was his favourite science topic during their school years. Both parents stated that science should be compulsory for junior secondary school. When asked about her career choice when she leaves school, Bree said “I want to research to find out something to help for cancer, and I want to be a nurse too”.

**Bree: Year Seven, Secondary School, 2005 (7R)**

Bree is in year seven at Meadows Secondary School. She is in Mr Ryan’s class and is the only case study student participant in her class, as she was in year six. Bree has remained interested in playing soccer and dancing when she is not at school and she also enjoys shopping. Bree’s favourite subjects at school are art, sewing and PDHPE (Physical Development and Health Education). Bree likes the practical lessons in science in secondary school particularly when she uses the laboratory equipment such as test tubes and thermometers. She said that she enjoys the ‘hands on’ experiences in science because “they are fun”. Bree also enjoys ‘the learning’ in science. Bree finds some aspects of science difficult like using dichotomous keys and she does not like writing down large amounts of information from the blackboard. Bree said when you are writing, “you are not really learning and it is sore on your hand”. If Bree were planning science lessons she would organise ‘hands on’ lessons where the students write down the instructions, then she would encourage the students to carry out the practical tasks. She would also show videos in science. When asked about the purpose of science in school Bree said, “you do science so you know how to do things in the future, like if you want to do chemicals and stuff in the future, if you want to be like one of them, you know how to do it”. Bree appeared to be enthusiastic and focussed during the practical lessons and carefully followed the teacher’s
instructions. Bree completed all her work and took part in the class discussions after the practical tasks. Bree’s work in her science book is excellent and she received a mark of 10/10 for her science book. Her practical lessons were well detailed and complete. Mr Ryan said that Bree is “performing to her ability, she is motivated but could be more motivated”. However Mr Ryan said he is quite happy with Bree’s progress. When asked to compare primary school with secondary school Bree responded by saying, “I thought secondary school would be lots of writing down and I did not think it would be so much ‘prac’. It is better than I expected. Science in secondary school is a bit more like science, in primary school it was not as much science it was all different things. You did not have a set time to do it, your just did it whenever and you did not get enough, I think”. Bree discussed how the students are told what will happen before they perform a science experiment in year seven. Bree said, “it is not as exciting, like he tells us that the balloon is going to burst or something. I would rather discover”. Bree said that she would like more time to do practical lessons because when the students have finished writing down the information from the board, often there is not enough time remaining to do the experiments. Bree achieved a ‘Science interest’ score of 61 in an attitudinal science survey administered in year six. Bree’s ‘Science interest’ score for the same attitudinal survey completed in year seven was 50, which was lower than the mean score of 53 for year seven non-participant students at Meadows Secondary School and this decrease in score is considered to be substantial.

The qualitative data gathered from interviews, focus groups, and observations suggest that Bree is still interested in some aspects of science like the practical lessons and how she ‘learns new things’ in the subject and she enjoys the fact that science is more regular in secondary school. However, she particularly enjoyed the ‘discovery learning’ in primary school and is disappointed that she is not given the opportunity to plan investigations in secondary school. Bree would prefer not be told by the teacher beforehand the likely results of the experiments and does not like copying notes in science. When asked what career she would like to follow when she leaves school, Bree replied, “I want to do something with drama and art maybe, but I am not sure”.

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Narrative for Cara

Cara: Year Six, Primary School, 2004 (6H)

Cara is a high ability year six Student, in Mr Beck’s Opportunity Class at Tuckeroo Primary School. She likes playing outside and watching TV. Cara’s favourite subjects at school are English and Science. In response to the question “what do you like about science” Cara said she likes “finding out different things, making things and experimenting with stuff”. Cara said that there is nothing she dislikes about science apart from “spending lots of time” finding information for her research, as it can be difficult sometimes. Cara scored 68 for ‘Science interest’ in a quantitative attitudinal survey (the mean score for year six was 58). She believes that it is important to have fun while you are learning. She mentioned that some people in the class draw and write while Mr Beck is talking. Cara said “if a teacher was explaining something and had gooey stuff or experiments or something like that in front of the class, and he started explaining stuff to us, we would keep an eye on it and pay attention to it”. She also said that it would be good to do an experiment after the teachers’ explanation. While observing Cara during a science lesson, Cara did not appear to listen as she was talking to the student next to her while Mr Beck was explaining facts about electricity. However, Cara seemed focussed during a video on electricity. During a practical lesson on electric circuits, Cara initially appeared enthusiastic about setting up a circuit but when another student in her group started setting up the equipment, Cara appeared irritated and withdrew from participating in the activity. She spends a great amount of time researching and her bookwork is outstanding with drawings, photographs and extensive notes. Mr Beck is most impressed with the improvement in the past year in Cara’s overall work. Mr Beck said that “Cara’s interest in science is unbelievable and I initially thought she was getting outside help but she just loves doing the work and finding out the information”. Cara seems very keen to show me her book each time she completes one. She appears to complete a book for every topic. In a survey completed by one of Cara’s parents it was stated that they liked science at school “most of the time”. Cara’s parent believed science should be compulsory for children of all ages and “practical science is always an advantage as it helps you remember”. When Cara finishes school she “wants to find a cure for cancer”.

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A poem from Cara’s journal

“Science is neat
It has lots of power,
Science can grow,
As can a flower,
Science is like,
Electricity in light,
Science can help,
People in flight”.

Cara: Year seven, Secondary School, 2005 (7K)

Cara is now in year seven at Meadows Secondary School. She is in Mrs White’s class, which is one of the two equal high ability classes. When Cara is not at school she draws, watches TV, works on her computer and plays with her cat. She also likes to ride her bike, play handball and draw chalk figures on the road. Cara’s favourite subjects in secondary school are metal and wood technology, art, cooking, sport and PDHP. Cara finds secondary science more interesting than primary science and she said that she likes experiments, watching videos and “learning new stuff” in science. Cara does not like looking things up in a book during science lessons and she particularly does not like writing in her book. She said copying notes from the board “sucks, because you stop for a second and then you have heaps and heaps of stuff to do because they (the teachers) just keep writing it and it is really annoying”. If Cara planned the science lessons she would do experiments every day except for one theory lesson. She would allow people in the classroom to talk, unless the teacher was talking. Cara said that she believes school science lessons help people “if they are trying to get a job” and they help people “trying to do things at University”. When we discussed what would happen if students did not do science at school Cara said, “you wouldn’t know as much, you couldn’t be able to specify things like animals and everything”. While I was observing Cara in her science lessons she appeared motivated and engaged during her practical lessons and she paid attention during the teachers demonstration of the practical activities. Cara was interested in asking questions during the class discussion. During a theory lesson Cara did not appear to be paying attention. She was sitting at the back of the classroom and she was playing a game
of paper golf in her science book with Alec, who she was sitting with. When asked to complete an answer to a question from the black board, Cara waited until the correct answer had been discussed before attempting to write the answer. Mrs White said that Cara was interested and engaged in science and her attitude towards science seemed good. However Mrs White said, “sometimes Cara’s concentration wavers, and she becomes distracted by the other students. Mrs White believes that Cara is not achieving at the level she would have expected and she said that Cara “could be doing better”. Cara’s bookwork is beautifully done. Her book is very neat and well detailed. Cara’s scientific drawings and other illustrations appear excellent. However Mrs White made a comment in Cara’s book asking her to take more care with her scientific drawings. When asked to compare science in primary school and secondary school, Cara responded by saying, “in primary school the teacher just wrote stuff up on the board and we had to copy it down. Like we got the information and stuff and we figured out what we had to do and then we just had to go home and do that, and we didn’t have like really hard topics or anything. In secondary school we have to use books, but in primary school the teacher mostly liked computers, because that is where he (the teacher) got his information. The teacher expects a lot more from you in secondary school. One thing I liked about primary school is you would do your science experiments and if it was not what the teacher expects or if it was not as good as what they want they don’t really care, or they care but they just ask” “if you do a really bad job (in secondary school) you will get into trouble, not me of course,” she said.

Cara achieved a high quantitative ‘Science interest’ score of 68 in the attitudinal science survey administered in year six. Cara’s ‘Science interest’ score remained high in the same attitudinal survey in year seven, as she scored 65, well above the mean of 53 for year seven students at Meadows Secondary School (this mean score did not include the 20 participant students’ interest scores). Cara has appeared to maintain her interest in, and positive attitude towards science, in most aspects of the subject, over the primary/secondary interface. However she is not achieving as highly in secondary school science as she was in primary school, and from my observations both in primary school and secondary school it was apparent that she was not engaged and appeared distracted while the teacher was talking. In primary school Cara excelled with her outstanding science research projects. In secondary school the students appear to do less research work. Cara still would like to find a cure for cancer when she leaves school.
Charlotte is in year six, in Mr Macpherson’s class at One Tree Primary School. Charlotte said she likes “to make up dances, play cards and research” when she is at home. Charlotte’s favourite subjects at School are English and Maths. Charlotte likes to do experiments in science because they are fun. She likes to “learn things about stuff in science and learn about other people and what they do”. If Charlotte planned her science lessons, she would make them fun for everybody. She said that she would present different activities, “like making light bulbs and stuff, because everybody likes those sorts of things”. Charlotte does not like writing in science because she finds it boring. She would like to use a video camera and photographs in science to record the results and other information, rather than writing. Charlotte said that she finds it difficult when her teacher talks about “things” she does not understand in science. She said that she is prevented from asking questions about “these difficult things”. Charlotte appeared to be interested in the practical class activities relating to electricity. She worked with her friend and wired up the circuits. She appeared to lose interest when she could not get various parts of the circuit to work. She was focussed during an investigation observing mystery liquids and using her senses to identify the liquids. However she did not accurately record the results. She appeared to listen to the teacher during the class discussion and was keen to answer questions during this time. Mr Macpherson said Charlotte “always had a go in science” but she requires help with all her subjects. Mr Macpherson said Charlotte appears to rely on her friends during practical science lessons and she often spends her time in science walking around and talking to her friends. Charlotte’s book is a little untidy with messy writing and unclear illustrations. She appeared to show interest and a positive attitude towards the practical aspects of science. Charlotte would like to work as a teacher or a lawyer when she finishes school.

Charlotte is in year seven at Meadows Secondary School. She is in Mr Davidson’s class. When Charlotte is not at school she likes creating dances with her older sister as she did when she was in year six. Charlotte also likes spending time with her friends at the
local swimming pool. Her favourite subjects at secondary school are maths, science and art. Charlotte likes the practical science lessons where she is able to participate in activities such as playing with magnets or using the Bunsen burners, and she enjoys the group work with her friends in science. Charlotte said that she enjoys the practical science lessons because they are “fun” and she “learns new things”. However sometimes she finds it difficult to light the matches, as she is afraid of burning her hands. Charlotte liked the fact that in science when she asked the teacher if she could organise a particular activity, the teacher usually presented the requested activity in the following lesson. Charlotte said she does not like a large amount of writing in science because “she would rather be doing prac”. She also dislikes the seating plans for the students in science. If Charlotte was planning science she said that she would organise a large number of practical activities and make science “fun” and she would “probably do electricity and all that stuff”. Charlotte took care with her bookwork at the beginning of the year, but she has completed one book in science and has not purchased a second book. Since completing her book I noticed she does not always write up her notes or stick the relevant photocopies into a book, she appears to keep her notes on loose pieces of paper. When observing Charlotte in her science class, it appeared that she spent a large amount of time talking to her friends as she did when she was in year six. Charlotte did not appear focussed during theory lessons and she lost interest quickly during practical lessons. There are a large number of students with behavioural problems and learning difficulties in Mr Davidson’s class and he requires assistance from a second teacher and a special needs support teacher, to manage the class during science. It is often very noisy in Charlotte’s classroom and a difficult environment for the students to concentrate. Mr Davidson said that Charlotte is easily distracted and has trouble focussing on science. He believes she is distracted mainly due to the “social things” that are happening around her. He said that Charlotte “does not show much interest in science in the classroom” and he believes Charlotte is underachieving in science. Mr Davidson remarked how Charlotte’s class was overcrowded and that he believed the students could achieve more if the student numbers were reduced. When asked about the relevance of science lessons at school, Charlotte replied, “you do science so you can learn about stuff when you get older, so that if you want to be a person that knows about electricity and know what happens and stuff”. Charlotte added, “People would not go far in life if they did not have science”. When asked to compare primary school science with secondary school science Charlotte said that secondary school science “is fun at the
moment, but secondary school is harder than primary school”. During a focus group with her peers Charlotte said that she would rather be in primary school for science. She reflected on how her teacher in primary school set up activities where the students were able to investigate and discover the results. According to Charlotte the students were told the results before starting the experiment in secondary school.

Charlotte’s ‘Science interest’ score for attitudinal survey completed in year seven was 59, which was above the mean score of 53 for year seven students at Meadows Secondary School (this mean score did not include the 20 participant’s students’ interest scores). In year six Charlotte was sitting next to a friend while completing her attitude survey and her and her friend’s results were almost identical. Her friend’s attitude to science was not very positive. There appears to be conflicting ideas emerging from Charlotte’s interviews, focus groups, observations and teacher interview. Charlotte appeared enthusiastic towards science in her interview and stated that science was one of her favourite subjects, particularly the practical science and the use of the laboratory equipment. However Charlotte did not appear to show a large amount of interest in science in the classroom and this was confirmed during the interview with Mr Davidson. Charlotte is generally easily distracted. However, during an observation in primary school, she appeared quite engaged while carrying out the student centred investigation activities. When asked what career she would like to pursue Charlotte responded by saying, “I would like to become either a kindergarten or pre-school teacher, because I love little kids, or a day care person who looks after little babies, or a nurse”.

**Narrative for Clay:**

**Clay: Year Six, Primary School, 2004 (6T)**

Clay is in year six at One Tree Primary School. Clay likes to play rugby union and he is playing in the far North Coast team. He said “I got reserve in the national team”. He also likes to play soccer, touch football, water-polo and he enjoys swimming. He played cricket and tennis in the past as well. Clay said, “I am a ‘hands on’ type of person and I like action and things”. What he likes doing best at school is to write short stories, “real quick ones”. He also likes PE (or PDHPE, Physical Development and Health Education), science, sometimes handwriting and art. Clay likes experiments and making stuff in science,
particularly chemical experiments like “making potions”. He likes these activities because they are fun and he enjoys them. Clay said what he most dislikes about science is “writing heaps, the ideas and the planning”. He said he doesn’t like writing because it gives him a “headache”. Clay believes he does science at school because “he can grow up and know these things and know how things work”. Clay scored 68 in ‘Science interest’ in the quantitative attitudinal survey (the mean score for year six science is 58). During classroom observations Clay appeared distracted and he had trouble organising his work and staying on task. He became frustrated when he could not get his equipment to work during a practical task where he was putting together an electrical circuit. Once the students in his group managed to get the circuit to work, Clay was keen to “blow up the light bulb”. He was very confident and enthusiastic to talk about what he had been doing in the class discussion and to present his diagram. During another practical involving the use of observation skills, Mr MacPherson asked Clay to stop running in the classroom. Clay’s bookwork is reasonably well done with plenty of diagrams but his writing is poor. Mr MacPherson said how Clay struggles to remember instructions and he requires help academically. Mr MacPherson said how Clay and his two friends, Jake and Matt do everything together and often rush to do things before thinking them through. When asked what he would like to do when he leaves school Clay replied, “I want to play Rugby Union professionally and get a part time job at Bi Low or Macdonalds, so I have something to do when I am not playing rugby union. I need to think about what I do when I retire”.

*Clay: Year Seven, Secondary School, 2005 (7H)*

Clay is in year seven at Meadows Secondary School and he started the year in Mr Davidson’s class. Clay was moved from Mr Davidson’s class (the lower ability class) to Mr Lee’s class after performing well in the mid-year exams. Clay likes to play rugby and soccer when he is not at school and he said, “I also like hanging out with my friends, playing sport and hanging around with my family”. Clay’s favourite subject in secondary school is maths, and Clay said “I like science second best when we do experiments, not writing”. Clay also likes PDHPE (Physical Development and Health Education), wood technology, sewing and art. Clay said he “gets to do fun stuff in science”. He particularly likes the practical lessons and he enjoys learning new things in science. Clay likes doing research projects as he enjoys typing and researching plants. He also enjoys going out into
the grounds to observe “nature” during science lessons. Clay does not like writing in science because when he writes he said, “I get a headache and it is very boring”. He finds reading in science difficult. If Clay was planning his science lessons he would organise more experiments, and some theory lessons, where he could do research and use the computers. He would regularly use the Bunsen burners in science lessons. In response to the question “why do you do science in school”? Clay said, “cause you wouldn’t know much stuff about our planet, animals and stuff” if you didn’t do science. Clay appeared distracted during the theory component of the first lesson I observed. When the class was asked to take part in the practical, Clay appeared very enthusiastic and followed the teacher’s instructions with his task. Clay was very focussed during the second practical lesson I observed and discussed the task enthusiastically with his friends and the teacher. Clay appeared very keen to answer questions during the class discussion time; he called out answers to the questions without raising his hand and the teacher reprimanded Clay for his actions. Clay’s book was reasonably organised but a little untidy and his writing was poor. Mr Lee said that, “Clay has the ability in science but is not working to his full potential”. Mr Lee went on to say that, “Clay is continually seeking attention and ‘butts in’ during instruction”. Mr Lee said that Clay is sometimes interested in practical tasks but he loses interest very quickly. Mr Lee believes that “Clay’s attention seeking behaviour is holding him back”. However when asked how Clay was performing in science Mr Lee told me that Clay is ranked third in the class with his assessment. When asked to compare science in primary school and secondary school Clay responded by saying, “in primary school we used to do nothing, not much, then we do it (science) every day here”. Clay prefers secondary science as he said he gets to “do more hands on stuff and that”. Clay achieved a high ‘Science interest’ score of 68 in an attitudinal science survey administered in year six. Clay completed the same attitudinal survey in year seven and his score was 66, which was well above the mean score of 53 for year seven students at Meadows Secondary School (this mean score did not include the 20 participant’s students’ interest scores). Clay has maintained his interest in science and his positive attitude to the subject over the primary/secondary interface. This is confirmed by his high ‘Science interest’ quantitative score and by the data from interviews, observations and focus groups. Clay would still like to follow his dream and play professional rugby when he leaves school.
Appendices

Narrative for Daniel:

Daniel: Year Six, Primary School, 2004 (6S)

Daniel is in year six at Hillside Primary School and he is in Mrs Pryor’s class. Daniel likes playing sports, such as tennis, soccer, bike riding and swimming. Daniel said that he also enjoys “playing with his dog, watching TV and sometimes writing”. Daniel’s favourite subjects at school are maths, sport and English. Daniel likes ‘hands on’ activities which he finds fun and he said he enjoys “drawing diagrams and learning stuff” in science. He particularly likes mixing chemicals together in science. Daniel does not like writing in science or listening to teachers talking in science, as he finds those things “boring”. He believes the reason he studies science in school is because he learns about “things that he would not learn about in maths or English”. Daniel went on to say, “you learn about countries, what things are made of, what two things create different gases, in science.Basically school science is “for life experience”. Daniel appeared to be confused about the difference between geography and science. He believes learning about the geography of different countries is part of science. The fact that the students in Daniel’s class use the same notebook for both geography and science, may add to the confusion. Daniel’s book was a little untidy and he had not separated the two subjects. During two practical science lessons, Daniel was focussed and appeared to enjoy what he was doing. He worked systematically through the tasks with his friend and recorded his results. He presented his work with confidence to the class, during class discussion time. Mrs Pryor, Daniel’s teacher, said that Daniel appeared highly interested in science, particularly taking part in any sort of investigation. She said Daniel is always keen on the practical work but he does not like the written work. Daniel’s father thought that his school science was fun, but he remembered the boys “not getting a go in science”. Daniel’s father believes that science should be compulsory for all ages as it “explains what is happening around us”. Daniel’s ‘Science interest’ score in the quantitative attitudinal survey is 59 (the mean score is 58 for year six). Daniel does not know what he wants to do when he leaves school.

Daniel: Year Seven, Secondary School, 2005 (7S)

Daniel is in year seven at Meadows Secondary School and his teacher is Mr Stokes. Daniel likes to watch TV and play sport when he is not at school. His favourite subjects at
secondary school are, maths, science, PDHPE (Physical Development and Health Education) and English. Daniel said that the practical lessons in science were "the best" part of science. He enjoys using the Bunsen burners, looking through microscopes and learning how things work. He said he likes the practical lessons because they are "fun and he gets to look at things instead of being told what they look like". He said that he "learns well by doing". Daniel described science theory as 'good" and when asked if he likes writing Daniel replied, "yes I don't mind it, cause I finish it really early and I can rest for the rest of the lesson". However in a survey (later in the year) Daniel said that he does not like a large amount of writing in science because it can "be boring and strenuous on your hand". Daniel said his least favourite topic in science was "animals" because there were very few practical lessons in that topic. Daniel does not find anything difficult in science. If he planned his science lessons he would organise practical lessons with some writing about the practical before performing the task. Daniel added "I would make them do a lot of bookwork before they got anywhere near the prac". Daniel believes that science is presented in school to prepare students for a career in science. Daniel said, studying science "will help us adjust, just in case later in life, no one knows if they are going to be a scientist or what not". Daniel went on to say that studying science in school "helps you work out how things work around you". While participating in a practical activity Daniel appeared focussed and engaged. He was keen to take part in a class discussion after the practical task. During a theory lesson Daniel appeared to listen when the teacher was talking. He completed a worksheet in the theory lesson, the worksheet had been given to the students previously to complete as a homework task. Daniel’s science bookwork was well detailed but his worksheets were poorly organised and his book was untidy. Mr Stokes believes Daniel enjoys science and he said that he thinks that Daniel has a general interest in science. He said Daniel asks questions in science and asks for clarification about certain areas at times but he does not think Daniel has reached his full potential in science and Mr Stokes believes if Daniel “worked a bit harder in science” he could achieve a higher grade.

Daniel achieved a ‘Science interest’ score of 59 in an attitudinal science survey administered in year six. Daniel completed the same attitudinal survey in year seven and his score was 68, which was well above the mean score of 53 for year seven non-participant students at Meadows Secondary School. This increase in ‘Science interest’ is
considered to be substantial. When asked to compare primary school and secondary school science Daniel said, “secondary school is better and there is prac work”. Daniel said that primary school science “wasn’t exactly science, it was just looking at how science kind of works. This (secondary school science) is doing science”. He went on to say “I was thinking hopefully we would be doing a bit more prac than this, but this is good”. During a focus group with his peers Daniel said, “in primary school we did absolutely nothing to do with science. It was just once every couple of months, okay look at this, ooh we have finished science”.

It appears from Daniel’s quantitative ‘Science interest’ score and from the interviews, focus groups, teacher interviews, and observations that Daniel has maintained his interest in science and his positive attitude towards the subject. Daniel may be developing a ‘personal interest’ in science as he clearly prefers science in year seven and the subject has become one of his favourites. Daniel does not have any ideas at this stage, regarding what career he will follow when he leaves school.

**Narrative for Ethen**

*Ethen: Year Six, Primary School, 2004 (6H)*

Ethen is a high ability year six Student, in Mr Beck’s Opportunity Class at Tuckeroo Primary School. Ethen is a very good chess player and he is in a team where he plays competition chess. He also enjoys using his computer for games and research. Ethen said his favourite subjects at school are science and maths because “I am a very good mathematician”. Ethen likes exploring and discovering new things in science. He said he particularly likes experiments and research because they are “fun and I like doing them”. He said that he believes science is good for “your occupations”. Ethen would like to become a vet when he leaves school, so he can work with animals. He said if he was in charge of organising science he would like to do practical science and he thinks it would be a good idea to learn about nature and plants, “so you know what is poisonous”. Ethen said that he does not like doing writing in science as he finds it “boring”. He would like to attend field trips as part of his year six science. Ethen said that science “tells you about everything around the world so if you meet something you will know about it. If there is a snake you will know if it is poisonous or harmless”. Ethen has taken care with his
bookwork, it is well detailed and he finds drawing diagrams difficult but puts effort into
the task. Ethen was engaged and focussed during a practical science lesson and appeared to
be interested in a science video on electricity that he was watching during a science class.
However, Ethen did not appear to pay attention during a theory lesson when Mr Beck was
talking. Ethen made an electric circuit at home (with the help of his father and uncle) as
part of a science project. Ethen was very keen to show me how it worked and appeared to
have a good understanding of various aspects of the topic. Mr Beck said that Ethen is one
of the brightest students in his class but he is younger than most of the other students in
year six and Mr Beck thought that Ethen had not put a great effort into science. He did not
feel that Ethen showed a particular strength in science at this stage. Mr Beck said that
Ethen had overcome many problems this year, and now he accepts that he may not always
come “top” in everything. One of Ethen’s parents does not remember much of his/her
science but thought science was “probably okay”. He/she believes that science should be
“very practical and involve inventive, mind boggling stuff that impact on today’s everyday
living”. Ethen’s ‘Science interest’ score in a quantitative attitudinal survey is 61 (the mean
score is 58 for year six). There was a question as to whether Ethen would be encouraged to
attend secondary school next year, as he was so young. However after further
consideration and consultation with his family, it was decided that he would move into
year seven at the beginning of 2005.

**Ethen: Year Seven, Secondary School, 2005 (7L)**

Ethen is now in year seven at Meadows Secondary School. He is in Mr Lyon’s class,
which is one of the two equal high ability classes. Ethen still likes to play chess and
computer games when he is not at school. Ethen’s favourite subjects at secondary school
are science, computer technology, industrial arts, visual arts, home economics and PDHPE
(Physical Development and Health Education). He said that he enjoys the experiments in
science because “they are fun, interactive and ‘entertainable’. Ethen also said that in
secondary school “instead of writing we do gluing”. Ethen does not like writing in science
as he finds it “boring”. He explained that he thought writing in science “shortens your
attention span”. He said, “writing fills up your book more quickly and students will muck
around more” while they are writing. Ethen does not find anything difficult in science. If
he was able to plan science lessons, Ethen would have an experiment each day, he would
make sure the experiments are explained well, and he would ensure that students are given help with their tasks where necessary. Ethen said that "science is a very important subject in terms of a necessary subject in school and you need to learn about all the things around you and if you want to become a scientist". He went on to say that science helps you learn to identify plants and animals, so if you find a new type of plant or animal you could become famous. Ethen said in science you learn to mix chemicals together so if you mix some new chemicals together you may accidentally create "a new potion or formula and that could make you famous as well". During the practical science lessons, where I was observing the participant students, Ethen appeared motivated and engaged. He worked efficiently and precisely with the laboratory equipment. He was particularly enthusiastic while observing pond water under a microscope. He appeared to be listening when Mr Lyons was speaking and seemed keen to answer questions during the class discussion time. Ethen appeared embarrassed when I asked to see his book and he said that he thought his book was "messy". His book was carefully detailed and generally well done and he received a bookmark of 8/10. Mr Lyons said that Ethen is very interested in science, "he tries very hard" and Ethen often asks him questions about science outside class time. For example Ethen asked Mr Lyons questions about 'light waves' and was keen to experiment with the laboratory equipment for the 'light topic' during his free time. Mr Lyons said that Ethen was ranked third in science in the year. However, he said that Ethen had a few social problems and was younger than most of the other students in his class. He believes that Ethen will achieve even higher results when he matures further. In year six Ethen achieved a quantitative 'Science interest' score of 61 in the attitudinal science survey. His 'Science interest' score for the same attitudinal survey in year seven was 60, well above the mean score of 53 for year seven students at Meadows Secondary School (this mean score did not include the 20 participant students' interest scores). Ethen said the he would now like to be "a computer technician, a geologist or someone who makes remedies for plants such as a remedies biologist". It appears that Ethen has maintained his keen interest in, and positive attitude towards science, over the primary/secondary interface and has developed a 'personal interest' in science, particularly as he related science to his life outside the school classroom. When asked how he would compare primary and secondary science, he said that he particularly enjoys the fact that he does more practical lessons in secondary school and less writing. He said that he did not do any experiments at primary school last year apart from research projects that the students undertook at home. Although Ethen enjoyed
doing the research task he had recently completed in science, he said that he would prefer to be doing more research in secondary school, like he did in primary school.

**Narrative for Harry**

*Harry: Year Six, Primary School, 2004 (6S)*

Harry is a mixed ability student in year six at Hillside Primary School and he is in Mrs Pryor’s class. When Harry is not at school he likes using his play station and playing with his dog. Harry’s favourite subjects at school are maths and reading. Harry said that he likes ‘hands on’ science and building things because its “fun”. Harry also enjoys mixing up chemicals and if Harry planned his science lessons at school, he would present more experiments where the students can mix up chemicals. Harry believes that there is “too much writing” in science and he dislikes this task. Harry said that he does not like listening to teachers or other “old people talking on and on about science”. Harry also finds it frustrating in science when he builds a model and cannot get it to work. He said that he does not “learn much” in his science lessons. He said that science is presented in school, as it is “helpful for education and for people following a career in science such as chemists, and people who work with electricity and stuff”. Harry’s science book is reasonably well done but a little untidy. During a classroom observation of a science practical, Harry worked alone. He had trouble organising his equipment and did not complete his task. Mrs Pryor said that Harry has problems socialising this year and he is not focussed. Mrs Pryor went on to say that he is sometimes keen but on “some days” his social problems appear to affect his motivation to take part in science. Mrs Pryor said, I think he would enjoy it, given the opportunity, if he was accepted into groups”. Harry does not know what he wants to do when he leaves school. His ‘Science interest’ score in a quantitative attitudinal survey was 60 (the mean score is 58 for year six).

*Harry: Year Seven, Secondary School, 2005 (7S)*

Harry is in year seven at Meadows Secondary School and his teacher is Mr Stokes. Harry likes “being at home, playing with his dog and running around the oval” when he is not at school. His favourite subjects in secondary school are history, maths, sewing, woodwork and art. Harry likes the practical lessons in science because they are ‘hands on’ and “you get to do something besides writing”, he said. Harry continues to dislike writing
in science and he said that he believes he does “too much writing” in the subject. Harry expressed his ideas for his science classes, he would reduce the theory, “sum it up to one thing, burn the books and use worksheets”. When Harry was asked about the relevance of science classes in school he responded by saying, “to learn how things react to other things, what some things are and all that stuff”. During a practical science lesson, Harry set up his practical task alone. He appeared motivated and engaged while carrying out the task but became frustrated when a student tried to tamper with his equipment. He packed away his equipment willingly and appeared to listen while his teacher was talking. Harry was engaged at all times during my classroom observations despite other students demonstrating “off task” behaviour. However he did complete an activity sheet during class time, this sheet was previously given to the students as a homework task. Harry’s bookwork is incomplete and messy. Mr Stokes said that Harry was “an individual who likes to work by himself. He loves the pracs and he is always on task”. Mr Stokes discussed how there were “some social issues” with Harry and how he has noticed some “underlying bullying” towards Harry, which Mr Stokes does not tolerate in his classroom. Harry is ranked first in his class in his assessment. When asked to compare primary school science and secondary school science, Harry said he likes secondary school science more. Harry achieved a ‘Science interest’ score of 60 in an attitudinal science survey administered in year six. Harry completed the same attitudinal survey in year seven and his score was 50, which was below the mean score of 53 for year seven non-participant students at Meadows Secondary School. This decrease in ‘Science interest’ is considered to be substantial.

The results in the quantitative attitudinal survey suggest that Harry has become less positive towards science over the primary/secondary interface. In contrast to the reduction in Harry’s ‘Science interest’ score, Harry stated that he likes secondary school science more than primary school science. Harry shows interest in the practical science lessons and this is supported by data from the interviews, focus groups, teacher interviews and observations. These data confirm that Harry is motivated towards, and is achieving highly in, secondary science. However he particularly dislikes writing in science and believes there is too much writing in the subject. This strong dislike of writing in science, and the social issues that frustrate him in the subject may impact on Harry’s attitude towards the science. Harry does not have any idea what career he will follow when he finishes school.
Narrative for Jake

Jake: Year Six, Primary School, 2004 (6T)

Jake is in year six at One tree primary school, in Mr Macpherson’s mixed ability class. When asked what he likes to do when he is not at school Jake said, “I like to play on the computer and ride my bike”. Jake does not like any subjects at school. He thinks that “experiments” are the best part of science. He prefers experiments in science because he said, “they are interesting and fun and you can see how you can make stuff”. Jake does not like writing in science because he finds it “boring”. Jake also said that he does not like “doing the same stuff over and over” in science. If Jake was planning his science lessons he would do “practical stuff, like making goo”. While taking part in a classification activity Jake said to a friend “this is boring”. However, he appeared engaged with the task and completed it. He seemed to be self-conscious and nervous when asked to discuss the results of the activity in front of the class. Jake was distracted while making an electric circuit with his friend Clay, they were disorganised with their work and had difficulty staying on task. During an activity where the students identified substances using their senses, Jake rushed through the activity and finished quickly. Mr Macpherson told Jake that he had not completed the activity correctly. Jake’s bookwork is reasonably well organised, the illustrations well done but his writing is untidy. When asked why he thought science was presented at school Jake replied, “if you stopped doing science you would do boring maths”. Mr Macpherson said, “Jake is very capable but does not work or put the effort into science, he doesn’t want to work”. Mr Macpherson said that Jake does not show any interest in science or any other subject, but he thought Jake liked the practical activities in science. He went on to say, “Jake, Clay and Matt like to do everything together and rush to do things without really knowing what they are doing”. Jake achieved a low score of 50 for ‘Science interest’ in the attitudinal quantitative survey (the mean score for year six was 58). Jake does not know what he would like to do when he finishes school.

Jake: Year Seven, Secondary School, 2005 (7H)

Jake is in year seven at Meadows Secondary School and he is in Mr Lee’s class. Jake said that he likes “playing sport and going to friends houses” when he is not at school. His favourite subjects at secondary school are wood technology and art. Jake said he likes
experiments because “they are fun to do and you don’t have to write much”. He does not find anything difficult in science. Jake does not like writing in science because he said it is “boring”. Jake also dislikes it when the teacher is talking in science. Jake does not know why he is required to do science in school. If Jake planned his science lessons he would let the students do anything they want and allow them to talk to their friends. He would not do any writing in science and he would let the students use the computer to do their work.

During an observation of Jake’s science lesson while the teacher was talking, the students who were sitting in front of Jake were throwing equipment at him causing him to be distracted. During the practical part of the lesson, Jake appeared interested in the science equipment but did not appear to be following the teacher’s instructions. During a second practical lesson, Jake listened while the teacher was talking and appeared to be engaged during this session. However, the practical finished very quickly as time was limited.

Jake’s bookwork was very rough and most work seemed to be incomplete. The drawings were poor and it appears that work was missing. Mr Lee said that Jake has the ability but is not performing to his ability. He went on to say that Jake was working well below his potential. Mr Lee said Jake is “intelligent but refuses to use it in favour of disrupting the good and rather than succeeding academically he likes to disrupt other people”. He said that Jake is not interested in science and has a poor attitude towards the subject. When asked to compare primary school and secondary school science Jake said, “in primary school you used to write stuff and get shouted at. He said in secondary school “there is some difference, you do like experiment things”. He said he enjoyed secondary science more than primary science. Jake achieved a low ‘Science interest’ score of 50 in an attitudinal science survey administered in year six. Jake completed the same attitudinal survey in year seven and his score was 52, which was similar to the mean score of 53 for year seven students at Meadows Secondary School (this mean score did not include the 20 participant’s students’ interest scores). Jake’s interest in science appears to have improved very slightly over the primary/secondary interface and he shows some interest in the practical lessons. His attitude towards science is not very positive as his attitude to school in general. However Jake is in a class where little time is spent undertaking practical tasks. Jake still does not know what he will do when he finishes school.
Narrative for Leigh

Leigh: Year Six, Primary School, 2004 (6S)

Leigh is a high ability student in Mr Beck’s opportunity class at Tuckaroo Primary School. Leigh likes to use her computer, read and watch TV when she is at home. Leigh’s favourite subjects at school are English and art. Leigh said that “experiments in science are fun, particularly chemistry”. She enjoys mixing weird substances together to see what happens. Leigh would like to be shown an experiment and be able to “figure it out” for herself. She said, “if you see the experiment you understand it more and if students are having fun they understand it more”. She believes every science lesson should have at least one experiment. Leigh does not find anything difficult in science but she said learning theory in science is “boring”. She also said that when the teacher talks for long periods of time, “it is really boring”. Mr Beck said that Leigh suffers from chronic fatigue and that she becomes very tired in the afternoon and often goes home at lunchtime. Consequently Leigh has missed a number of science lessons as science is usually presented in the afternoon. Mr Beck said Leigh had not finished many of the topics and he went on to say that Leigh was very bright and did well in external tests. Leigh was always polite and enthusiastic when I conducted my research activities with her. As she was absent so often in the afternoons, it was not possible to observe Leigh in a science lesson. Leigh achieved a ‘Science interest’ score of 62 in a quantitative attitudinal survey (the mean score for students in year six is 58). Leigh is not sure why she does science at school. She said she thought that “maybe it depends if you are going to work with scientific things or not”. When asked if you would need science if you were not planning to work in a science field, Leigh replied, “you may still want to learn about science in case you had to do something with it”.

Leigh: Year Seven, Secondary School, 2005 (7L)

Leigh is now in year seven at Meadows Secondary School. She is in Mr Lyon’s class, which is one of the two equal high ability classes. Leigh continues to suffer from chronic fatigue and is frequently absent. However towards the end of the year Leigh was not absent so often. Leigh still likes to use her computer and watch TV when she is at home and she just likes to do “fun stuff” she said. When discussing her subjects at school Leigh said her
favourite subjects are “probably cooking and woodwork, science is alright except it is not that fun and maths is pretty good and that will about do it”. Leigh particularly likes experiments in science. She said that she finds experiments interesting usually because “you don’t do the same thing over and over again”. Leigh went on to say that experiments “are fun, you don’t get bored and they are a break from writing”. Leigh does not find anything in science difficult in year seven. She said that she would prefer to do a bit less “writing stuff down” in science. Leigh thinks that she does not do enough experiments and that writing in science is “boring”. If Leigh was planning science she said she would get out all the fun stuff, all the cool stuff and let the kids play around with it” for example; “static balls, Bunsen burners and stuff” she said. When discussing experiments she would prefer not to know what is going to happen and she said if you don’t know what is going to happen before you do an experiment you may think, “Ooh what’s going to happen? Let’s watch closely and pay attention”. During the observations of Leigh in her science classes, she appeared focused during the theory sessions and motivated and engaged during the practical lessons. She set up her equipment efficiently with Tia’s help, and they recorded the results precisely. Leigh appeared very interested and fascinated while observing pond water under the microscope. Leigh’s bookwork was less detailed as she had been absent frequently from science. Her bookwork was neat at the beginning of the year but her work became less neat towards the end of her book. Mr Lyons said that Leigh had been doing very well despite her absences and he was surprised that she had achieved so highly as she had been absent so frequently. He went on to say that he thought Leigh was “focussed and interested in science”. Leigh believes that the reason science is presented at school is “so that you know how stuff works and what you should play with and what you shouldn’t, so you don’t play with dangerous substances and injure yourself” she said. When comparing primary school to secondary school Leigh said “it was really boring in primary school science, because you actually never did much experimentation and it was all writing it down and being told what would happen”. Leigh said, that “science is better in secondary school and you learn a lot more because you can actually see what is happening and you don’t just get told it”. Leigh also said that primary science was boring and compared to primary, “secondary science was excellent”. In year six Leigh achieved a quantitative ‘Science interest’ score of 62 in an attitudinal science survey, and her ‘Science interest’ score in the same attitudinal survey in year seven was 55, above the mean of 53 for year seven students at Meadows Secondary School (this mean score did not include the 20
participant students' interest scores). Even though Leigh’s ‘Science interest’ score is lower in secondary school, generally Leigh appears to have maintained her interest in, and positive attitude towards science and may even appear more motivated during her science lessons since she has progressed through the primary/secondary interface. When asked what she plans to do when she finishes school, Leigh said, “I don’t really know what I want to do. I will have figured it out by year ten when I take my electives”.

**Narrative for Martin**

*Martin: Year Six, Primary School, 2004 (6H)*

Martin is a high ability year six Student, in Mr Beck’s Opportunity Class at Tuckeroo Primary School. To help him relax when he is at home, Martin enjoys playing sport, teasing his sister and mucking around on his computer. His favourite subjects at school are science, maths and spelling. Martin loves to learn about new things in science and he has a passion for animals and nature. According to Mr Beck, Martin is extremely knowledgeable about animals. He is interested in environmental issues such as global warming and the resulting impacts on marine animals. He is enthusiastic to research these issues and is confident to discuss the consequences. Martin also loves the ‘hands on’ science. He said how he loves to do “experiments and research because they are fun and you are learning new stuff”. He appeared focused during a practical electricity activity where he made an electric circuit. One day when I arrived at the school and he ran out to meet me to share with me his experiences setting up an experiment to make water based ink. Martin and his friend Alec, found some ingredients at home and mixed them together to make a special paint. He showed me how he had carefully documented his work in his journal. Martin would like more time to do science at school, to research and do practical activities. He would prefer it if he did more “hands on” science in his class and less writing. Martin finds some areas of physics difficult and he believes that if he was to have more experiences with certain parts of physics, like looking at machines and how they work, he may be able to gain a better understanding of these areas. Martin thought it would be good when learning about a topic to go out on an excursion relating to what he was learning, for example, if he was studying water; he could go and look at a dam. He thought it would be good to have a pet in school when learning about animals, and he said, “I just do not do enough with plants and animals and that’s one of my favourite parts”. He would love to
use a microscope to dissect a flower or look at a plant cell. Martin scored 67 for ‘Science interest’ in an attitudinal quantitative survey (the mean score for year six was 58). He believes that science is important in school because it “moulds the kind of job you are going to do later on, say you were going to do zoology you would have to know a fair bit about animals and stuff like that, and if you were going to be a mechanic you would have to know about machines and how they work”. In a survey completed by Martin’s parents both parents stated that they liked science at school and one parent stated how experiments were stimulating. Martin said, “I could probably be a vet” in the future. Mr Beck believes Martin would certainly have the ability to achieve this goal. Martin appears to have a ‘personal interest’ in science in year six.

**Martin: Year Seven, Secondary School, 2005 (7L)**

Martin is now in year seven at Meadows Secondary School. Martin is in Mr Lyon’s class, which is one of the two equal high ability classes. When Martin is not at school he enjoys playing games, having fun and annoying his sister, as he did when he was in Primary School. His favourite subjects at secondary school are industrial arts, science, maths and home economics. He continues to love experiments and has maintained his interest in animals. He loves experiments because he said, “they are interactive and you learn things yourself”. Martin does not find anything difficult in science but he said he still does not like “mechanics and stuff”. He also said that sometimes science is “dangerous”. He continues to dislike a large amount of theory in science, as he would rather be doing “hands on” activities. Martin believes that his “attention span shortens”, when he does “continuous theory”. If Martin planned the science lessons, he would do a “little more practical lessons and just a little bit of theory”. He said he would also like to do more research “where you compare your research with other peoples” work. He would gradually change topics in science instead of “jumping from thing to thing”. Martin appeared motivated and engaged in all the science classes while I observed him. He particularly appeared focussed during practical activities and he was fascinated when looking under a microscope at organisms in pond water. Martin seemed keen to take part in class discussion after the practical activities. Martin’s bookwork was excellent, very neat and carefully detailed. He received a bookmark of 10/10. When asked to compare primary school and secondary school, Martin said that he did a large amount of writing, more
research in primary school and not many experiments. He explained how in primary school he thought it was funny “because one minute we would be doing maths and then the teacher would ask you to pull out your science book”. Martin expected “a bit more research and more experiments” in secondary school science. He said if he had to rate the subjects he would have given a score of 8/10 for primary school science and a score of 9/10 for secondary school science. Like Mr Beck in year six, Mr Lyons remarked on Martin’s interested in animals and how advanced he was with the classification of animals. Mr Lyons said Martin is “powering in science”, he had achieved very high marks in and had ranked fourth in the year in the subject. Martin believes that science prepares students for jobs such as scientists, chemists or any job that involves science. He also said that learning science could give people the knowledge of “what to mix together” to create “different things”. Martin achieved a high quantitative ‘Science interest’ score of 67 in the attitudinal science survey administered in year six. His ‘Science interest’ score for the same attitudinal survey administered in year seven was 63, well above the mean of 53 for year seven students at Meadows Secondary School (this mean score did not include the 20 participant students’ interest scores). It appears that Martin has maintained his passion for science and his ‘personal interest’ in the subject as he has progressed from primary school into high school. He likes science a little more in secondary school than he did in primary school. Martin said that he “probably will be a vet when he leaves school, but maybe something else”.

**Narrative for Matt**

*Matt: Year Six, Primary School, 2004 (6T)*

Matt is in year six at One Tree Primary School in a mixed ability class. He likes to play handball with his brother and also he loves to play with his “cute little nephew called Ben, who has no front teeth”. Matt’s favourite subjects at school are maths and sport. Matt likes “experiments and making things in science”. He does not like “writing” and he would prefer to “record things on the computer like a power point presentation” rather than writing in books. Matt does not like “doing things over and over in science”. Matt believes that you do science in school “cause it makes you get smarter and it’s fun for kids, so it is making you smart and making kids happy as well”. He said, “when you go to university or
something it will help in the brain smart”. Matt scored 68 for ‘Science interest’ in the attitudinal quantitative survey (the mean score for year six was 58).

Mr MacPherson said Matt told his mother that “it is not cool to work at school”. Mr MacPherson said Matt does not put a great effort into his work in any subject, including science. However, he said that Matt likes ‘hands on’ science and he likes to work with his friends, Jake and Clay. Mr MacPherson said the three boys find it difficult to work on their own and their decisions about their work are influenced by one another. While being observed during a practical lesson, Matt appeared focussed on the work at the start of the practical session. He was enthusiastic and confident to present his work to the class. However Matt appeared to be easily distracted by his friends after participating in the practical activity for some time. Matt’s mother completed a survey and it revealed that she liked science at school. Matt’s mother believes science should be compulsory for students of all ages and that natural science should be taught at primary school with an emphasis on the environment, particularly from “local indigenous groups’ perspectives”. When he leaves school Matt wants to “make a movie or make a band”; he also said “I am going to adopt a child that has no food over there in other countries”.

**Matt: Year Seven, Secondary School, 2005 (7P)**

Matt is in year seven at Meadows Secondary School and he is in Mr Davidson’s class. Matt likes to play soccer and watch TV when he is not at school. His favourite subjects at school are science, PDHPE (Physical Development and Health Education) and English. He said science is “fun” and he likes to do experiments. He enjoys using magnets and playing with fire and he likes practical lessons because they are better than “doing writing”, he said. Matt finds writing in science difficult and he does not like it as “it is boring and it hurts your hands”, he said. He also dislikes the students “calling out” and the “noise” in his science class. There are a number of students with learning difficulties and behavioural problems in Matt’s class, and there is often a second teacher and a special needs assistant helping him with classroom management. If Matt were responsible for planning his science lessons he would do “writing and experiments like Mr Davidson does”. He said he would do “interesting stuff instead of boring stuff”. In response to the question “why do you do science at school”? Matt said, “because when you get older you might be a scientist or
something like look at the stars and all that. You might be one of them peoples. The science teacher explains what things happen and what things do". During a practical lesson in science Matt appeared to be motivated towards, and engaged in, the task. He organised his equipment and followed the teacher’s instructions carefully. He discussed the results of his experiment with his peers. During the theory lessons I observed, Matt mostly completed his work, but became distracted on a few occasions. One of the assistant teachers said that Matt often assisted other students with their work, after completing his own. Matt was keen to take part in his science lessons and my interviews with Matt were rescheduled on a couple of occasions to avoid him missing out on practical tasks. Matt’s bookwork was a little untidy but comprehensive with most work complete. It appears that Matt takes care to complete his theory work and write notes after experiments. Mr Davidson said that Matt is sometimes interested and focused in science but other times he is distracted. Mr Davidson said Matt has achieved a reasonably high mark in his class but he believes that Matt could do better. Mr Davidson commented on how difficult it is for the students to “keep focussed” in his class as there is a large number of distractions. Matt said that, “secondary school is better than primary school” and he believes that he will do more things in science later on “like gases and all that”. He said he did not do “anything like that” in primary school. Matt achieved a high ‘Science interest’ score of 68 in an attitudinal science survey administered in year six. Matt completed the same attitudinal survey in year seven and his score was 67, which was well above the mean score of 53 for year seven students at Meadows Secondary School (this mean score did not include the 20 participant’s students’ interest scores). Matt has maintained his interest in, and a positive attitude towards, science in secondary school and he appears to prefer secondary school science. Matt said he would like to become a “policeman” when he leaves school.

**Narrative for Roxy**

**Roxy: Year Six, Primary School, 2004 (6T)**

Roxy is in year six at One Tree Primary School. Roxy likes to read books when she is at home and she also loves shopping with her friends. Roxy is training her pet budgie to talk and she also has a dog. Her favourite subjects at school are English, art and maths. Roxy said she likes science because “you get to learn new things and science is ‘hands on’”. Roxy thinks science is “fun” and she enjoys the experiments in science and particularly
likes how she works in groups with her friends. Roxy does not like writing or keeping notes in science because “it is boring”. However, she does like writing stories. Roxy believes that you learn more “when it is fun so you need to do fun things”. When asked why she does science at school, Roxy replied, “just to get better at it and to learn more things”. When asked what she would do if she was responsible for planning her science she replied, “I would do a survey to see what things people would like to do and put them all together and have an activity science day. Like making hot air balloons, or try and grow plants, or make a volcano”. Roxy discussed how she sometimes finds science difficult if she “does not know what to do”. However if she finds anything difficult to understand in science, “like words”, she will ask Mr MacPherson to explain them and then she “get’s it”. Roxy’s score for ‘Science interest’ is 66 (the mean score for ‘Science interest’ for year six is 58). During classroom observations Roxy worked systematically through all the activities, for example, she set up different electric circuits according to the diagram and tested each one carefully. During a practical lesson where Roxy and her peers were asked to design and put together an electrical circuit, Roxy appeared enthusiastic and eager to test different ways of assembling her circuit. She also assisted other groups of students with their circuits. Roxy appeared to be focussed during the practical activities that were observed and eager to take part in the class discussion after the activities. Mr MacPherson said that in the short time he had been teaching at the school, Roxy had “come ahead in leaps and bounds”. He said that when he first took over the class, the students “would not challenge anything in science” and that Roxy “gets out and does what she has to do”. Roxy’s bookwork in science is neat, well detailed and her drawings are well done. Roxy would like to be a lawyer when she leaves school but at times she wants to be a vet because she really likes animals.

Roxy: Year Seven, Secondary School, 2005 (7S)

Roxy is in year seven at Meadows Secondary School and her teacher is Mr Stokes. When Roxy is not at school she likes to watch TV, read and spend time with her friends. Her favourite subjects in secondary school are English, art and PDHPE (Physical Development and Health Education). Roxy likes the practical work in science, especially working with chemicals and observing cells. She likes learning new things everyday in science. Roxy does not find any aspects of science difficult and she said “my teacher
explains it (science information) and I understand most of it”. Roxy would like to do more experiments and less writing in science. She said that some of the words in science are “long and complicated” and she finds practical science “fun” and easier to understand. She would prefer to see the use of common names in preference to scientific names in science. If Roxy planned her science lessons, she would present activities where the students build working models and she would organise science experiments. She would like to see computers used more in science. Roxy believes students should use laptop computers in science, she said it would help “everyone get their work done”. Roxy is not sure why she studies science in school but she thinks it might help students if they require science for their careers. When observing Roxy during her science lessons she appeared motivated towards, and engaged in, the practical lessons. She volunteered to help the teacher while he was demonstrating the use of science equipment. Roxy and her peers worked through their tasks and willingly set up and packed away the equipment. During a science theory lesson where the teacher was discussing the answers to a worksheet, previously issued to the students as a homework task, Roxy spent her time completing the worksheet during class time and did not take part in the discussion. Roxy’s science workbook was well organised, very neat, and the diagrams were carefully detailed. Mr Stokes said, “Roxy is bright and bubbly and likes being there (in science) I think, because she just gets excited”. He thinks Roxy has a positive attitude towards science. However he said, Roxy is often eager to perform the practical tasks before the task is fully explained. He believes Roxy would gain more from her science practical activities, if she worked carefully through each step of her task, rather than rushing to gain the results. Mr Stokes said that Roxy is achieving reasonably well in science tests but he believes she could be achieving higher results with more preparation. Roxy achieved a ‘Science interest’ score of 66 in an attitudinal science survey administered in year six. Roxy’s ‘Science interest’ score for the same attitudinal survey completed in year seven was 67, which was well above the mean score of 53 for year seven students at Meadows Secondary School (this mean score did not include the 20 participant’s students’ interest scores). When asking Roxy to compare primary science and secondary science she said that secondary school science is very different to primary science. She believes secondary science is a higher standard and she said she likes using the chemicals and “different technology” in secondary school. She remarked how science classes are more frequent in secondary school but they are shorter in duration than they were in primary school. During a focus group with her peers, Roxy discussed how in
primary school she could complete her experiments over a longer period of time. She said that in secondary school, if an experiment is not completed by the end of the lesson, “we just have to leave it and go on with a new thing” the next day. Roxy stated that she would like more time to “actually discover” in science.

The results from both the quantitative survey and the qualitative data confirm that Roxy has maintained her interest in, and her positive attitude towards science across the primary/secondary interface. Roxy particularly enjoys the practical aspects of science but appears to find science theory less engaging. When Roxy finishes school she would like to become a lawyer as she did when she was in year six.

**Narrative for Tatiana**

**Tatiana: Year Six, Primary School, 2004 (6S)**

Tatiana is in year six at Hillside Primary School. Tatiana likes to read and listen to music. Her favourite subjects at school are music, English and drama. Tatiana likes experiments in science and she said when science is ‘hands on’, “it is easier to understand things and it is fun”. If Tatiana chose activities for a science lesson, she would do an experiment where something exploded, like adding sodium bicarbonate and vinegar to simulate a volcano. Sometimes she finds aspects of science tests difficult such as questions relating to electricity. Tatiana explained that she found it “frustrating when nothing happens during an experiment” and she went on to say, “I guess that’s what a lot of scientists do and probably get frustrated if nothing happens”. Mrs Pryor (Tatiana’s teacher) said that she did not think Tatiana enjoys science investigations, as she believes Tatiana likes to have certainty and investigations can be unpredictable. Mrs Pryor said “I think investigating makes her nervous because she does not like failure”. Tatiana dislikes writing in science. She believes that she undertakes science in school in order “to learn about how things work and what is happening around us”. During a science lesson Tatiana worked through the activities with her friends and they appeared to rush their work and finished the task quickly. However, Tatiana appeared reasonably interested and engaged while carrying out the tasks. Tatiana’s bookwork is very neat, well detailed and the diagrams are clear. Tatiana’s mother enjoyed the practical applications of science, particularly those that related to everyday life. Tatiana’s mother believes science should be introduced to
children early in school in order to prepare them for secondary science. Tatiana has thought about becoming a vet, a doctor, a lawyer or a teacher when she finishes school. Tatiana’s ‘Science interest’ score in a quantitative attitudinal survey is 52 and is below the mean score of 58 for year six.

Tatiana: Year Seven, Secondary School, 2005 (7K)

Tatiana is in year seven at Meadows Secondary School. Although in primary school she was in a mixed ability class she is in now in Mrs White’s class, which is one of the two equal high ability classes. Tatiana likes to listen to music and play the piano when she is at home, as she did when she was in primary school. Her favourite subjects at secondary school are music and language. Tatiana sometimes enjoys the experiments in science although some experiments “are boring” she said. Tatiana’s preferred topics in science are those relating to living things. She finds some aspects of science difficult, like “remembering all the different ways of separating mixtures”, she said. Tatiana does not like certain aspects of science such as, writing in science, learning ‘technical words’ and summarising information. She said that she “hates how drawings have to be perfect” in science. Her teacher wrote a comment in her book, suggesting her drawings were a poor standard. However, Tatiana’s drawings appeared relatively neat and well detailed, her work was very comprehensive and all work was complete. There was a large amount of writing in Tatiana’s book and she received a mark of 17/20 for her work. Tatiana described how she would plan her science, “I would prepare “lots of experiments”, she said. She talked about how she would explain the scientific conceptual information with the use of games or an experiment. Tatiana would prepare photocopies of notes in preference to writing, she would do more research in science and she said she would “not do as much reading in science”. Tatiana believes that she studies science at school because science is in “everyday life”. She said science would also help you if you wanted to become “like a doctor of something”. Tatiana said that she likes the fact that science “helps with medicine and finds cures for diseases like cancer”. When observing Tatiana in science she appeared keen and enthusiastic during a practical lesson. She gathered her equipment and carried out the teacher’s instructions. During a theory lesson Tatiana, appeared to be listening and wrote the correct answer to a question in her book. This suggested that she understood the conceptual information that was presented. Tatiana is ranked in the middle of her high
ability class with her assessment. Mrs White said that Tatiana appears to be interested and engaged during her science classes and she explained how Tatiana has some conceptual difficulties with certain areas of science. Mrs White said, “Tatiana is not afraid to ask” for help with her work and she described Tatiana as being “conscientious”. Mrs White stated that, “Tatiana does what ever is asked of her and does it to the best of her ability”. Tatiana achieved a ‘Science interest’ score of 52 in an attitudinal science survey administered in year six. Tatiana’s ‘Science interest’ score for the same attitudinal survey completed in year seven was 44, which was considerably lower than the mean score of 53 for year seven non-participant students at Meadows Secondary School and this decrease in ‘Science interest’ is considered to be substantial.

When asked how she would compare primary school and secondary school science Tatiana said, “I preferred science in primary school, because when we did science, like when we made a volcano and when we studied rocks we actually did a test with it (a fair test) and it was more ‘hands on’. Sometimes I think we did more experiments in primary, even though we did not do as much science. When we did do science in primary we did more experiments and the topics were a lot funner there”. Tatiana is thinking of becoming a lawyer, working with animals or working in a music career when she finishes school.

Tatiana is achieving high results in her year seven-science assessment, and she appears to be engaged during science classes. However, when looking at the reduction in Tatiana’s ‘Science interest’ score in year seven compared to year six, together with data resulting from interviews, surveys and focus groups, it could be assumed that Tatiana’s attitude towards science has become less positive, over the primary/secondary interface.

**Narrative for Tia:**

_Tia: Year Six, Primary School, 2004 (6H)_

Tia is a high ability student in Mr Beck’s year six opportunity class at Tuckeroo Primary School. Tia likes reading books, watching TV and playing games when she is not at school. Tia’s favourite subjects at school are English, science and art. Tia likes to do experiments and to make things in science and she said she likes learning about different things in science especially to do with “animals and the Earth and stuff”. Tia does not like
her teacher “talking for a long time about one subject”. The students in Mr Beck’s class have undertaken a number of science projects and Tia said sometimes it is hard to find information for these projects. She stated how her science projects take up so much time that she needs to work on weekends to get all her schoolwork completed. Tia believes it is good to learn all the different science subjects in school, particularly for jobs “where you need to know this stuff”. Tia was motivated and engaged during a practical lesson in class and worked systematically with her peers to set up electrical circuits. Tia said “it is more interesting if you can see it”. Tia’s bookwork is neat and carefully detailed, with excellent diagrams and is comprehensive. Tia’s Mother said that she found her school science exciting and diverse and enjoyed the practical experiences. Tia’s mother believes an introductory science unit with practical applications should be compulsory for students of all ages. Mr Beck said that Tia is a “bright student and has produced some good work in science but without much effort”. Mr Beck believes if Tia worked harder she would do better in science. Tia appeared to have a positive attitude towards science but found that the large amount of work expected of the students in science was difficult.

**Tia: Year Seven, Secondary School, 2005 (7L)**

Tia is now in year seven at Meadows Secondary School. She is in Mr Lyon’s class, which is one of the two equal high ability classes. When Tia is not at school she likes reading and watching TV, as she did last year. Tia also likes using the computer when she is at home. Tia’s favourite subjects at secondary school are art, industrial arts, science and English. Tia likes doing the experiments in science lessons because she finds them fun and more enjoyable than writing. If she planned the science lessons, Tia would have “lots of fun experiments and just write down a few things and not do too much writing”. She would also show videos in science. Tia believes that science in school helps with almost every job you have and she said, “if you want to be a Doctor you need to learn about mixing chemicals and next year we have to cut up like body parts or something my brother said, so we would need to learn about that if you want to be a doctor or a vet”. When discussing if school science was necessary if you were not planning to work in the field, Tia responded by saying “yeah you learn about lots of things, you learn about plants and cells and stuff”. During my observations of Tia in her science class she appeared focussed during the theory sessions and motivated and engaged during the practical lessons. Tia set up, the equipment with Leigh and they worked with precision, and carefully recorded their results; she
appeared to particularly enjoy observing pond water under the microscope. Tia’s science workbook was neat, comprehensive, carefully detailed and her bookmark was 8/10. Mr Lyons said “Tia is very focussed, concentrates well and she has done much better than I thought she was going to do and she came fourth” in the class. Mr Lyons went on to say “she is working well, interacts well and has an excellent attitude” to science. When Tia was asked how she would compare primary school and secondary school she responded by saying secondary school “is a lot different because at primary school we just wrote stuff off the board, we didn’t really do very much and now we sort of learn about lots of different subjects and we do experiments and stuff on them. We get to use equipment like Bunsen burners and all that sort of stuff, and beakers and we didn’t have any of that in primary school”.

Tia’s quantitative survey was incomplete in year six so her ‘Science interest’ score could not be calculated or compared across the primary/secondary interface. In year seven Tia achieved a quantitative ‘Science interest’ score of 58 in an attitudinal science survey, this was above the mean of 53 for year seven students at Meadows Secondary School (this mean score did not include the 20 participant students’ interest scores). Tia appears to be interested in, and have a positive attitude towards, science. She is achieving well in science and appears to have become more motivated towards science after progressing through the primary/secondary interface. Tia would like to be a vet when she leaves school.

**Narrative for Tyson**

_Tyson: Year Six, Primary School, 2004 (6H)_

Tyson is a high ability student in Mr Beck’s opportunity class at Tuckeroo Primary School. Tyson said that he likes to listen to music and watch “a little bit of TV” when he is not at school. Tyson’s favourite subjects at school are maths, art and sometimes science, “when its stuff that I like to do” he said. Tyson enjoys experiments and drawing diagrams in science. Tyson likes science that involves animals and nature and he also enjoys electronics such as working with electrical circuits. He likes animals because they are cute and electronics because he plays a lot of computer games. He said that he finds topics like electricity interesting and he likes “finding out stuff” in science. Tyson would like more
experiments and excursions in science. Tyson said “animal care would be interesting because kids have animals dying and it is a big drama. So I reckon they should be taught how to do it properly”. Special effects movies would also be interesting according to Tyson. Tyson said that he finds physics and chemistry a little difficult and he does not like “chemicals, mirrors or light” in science as he finds them complicated, but the rest of science he finds “pretty easy”. Tyson gained 51 for ‘Science interest’ in a quantitative attitudinal survey (the mean score is 58 for year six). Tyson believes science “gets us ready for the whole world that is coming towards us in the next few years”. Like it basically helps us to understand things that are very difficult to understand. Tyson was engaged and interested during a practical lesson on electricity. He experimented with different ways to arrange a circuit. Tyson’s bookwork was extensive and innovative. He had carried out an investigation on erosion, and he had photographed and documented the results. His computer work was excellent. He created excellent power point presentations to show aspects of electricity and chemical change. Mr Beck said that Tyson was keen with his science and that he had achieved the highest mark in a science test and he said that Tyson “had gone out of his way to do his own experiments at home”. Tyson’s mother liked science in junior high school, particularly the practical lessons. She felt intimidated in senior chemistry by the fact she was the only girl in the class. Tyson’s father also liked “hands on science”. Tyson appeared interested and enthusiastic towards science although his ‘Science interest’ score was lower than average.

Tyson: Year Seven, Secondary School, 2005 (7L)

Tyson is now in year seven at Meadows Secondary School. He is in Mr Lyon’s class, which is one of the two equal high ability classes. Tyson likes watching TV and reading when he is not at school. His favourite subjects at secondary school are home economics and computer technology. Tyson said that he likes experiments, particularly burning things and playing with fire. He likes lighting the Bunsen burners in secondary school. Tyson enjoys ‘hands on’ science and he said, rather than “just sitting down and writing stuff” he would like to be “doing stuff”. He said that the experiments in science “just keep on getting more interesting”. Tyson does not find anything difficult at the moment but he thinks that it will get more difficult later although he finds cells complicated. He said that writing is probably the worst thing about science. Tyson said that he thinks he does science
in school because “science has stuff all around us in it”. He thinks that science would help you if you were planning to become a scientist and you would also need to do some aspects of science even if you were not planning to follow a career in science. If Tyson was planning science in secondary school, he said he would organise activities like “boiling stuff with Bunsen burners, lots of experiments, videos and less writing”. Tyson would also plan research tasks in science as “they help you find out about things” he said. When asked ‘what he would not do’ in science if he was planning the subject he replied “nothing really, there is not much about science that I wouldn’t do”. During the first and second occasions where I observed Tyson in a practical lesson I noticed that he was engaged and he appeared to be interested. In one lesson he was observing objects with a hand lens and he with Martin, particularly enjoyed holding the lens in front of an overhead projector and almost managed to burn a hole in the whiteboard screen. However, on the third occasion where I observed Tyson in his science class, Tyson appeared to be distracted during the introduction to the practical tasks. He was the first to set up his equipment for the practical task and he lost interest very quickly with the task. After he had finished he attempted to distract some of the other students who were engaged with their practical activities. Mr Lyons said that Tyson had been more focussed in science in the first half of the year and that he does not appear to be as engaged in the second half of the year. Mr Lyons believes that this change in attitude might be as a result factors outside school, affecting his motivation towards his work. Mr Lyons said that Tyson is capable of achieving a higher mark in science if he made more of an effort. Tyson’s bookwork is very detailed and neat although some parts are incomplete. He received a bookmark of 10/10. When asked how he would compare primary school and secondary school Tyson said that in primary school “we did absolutely no experiments at all, all we did was write and it was kind of boring compared to this (secondary school)”. In year six Tyson achieved a low quantitative ‘Science interest’ score of 51 in an attitudinal science survey. His ‘Science interest’ score for the same attitudinal survey in year seven was 48, below the mean of 53 for year seven students at Meadows Secondary School (this mean score did not include the 20 participant students’ interest scores). However Tyson appeared focussed last year in primary school particularly when he took part in a practical lesson that I observed and when he carried out his own research task at home. Tyson was very engaged when creating a ‘Power Point’ presentation to explain conceptual information about a science topic in year six. Tyson enjoys the fact that he takes part in more practical lessons in secondary school, but he
would like to take part in more independent research in science. He also enjoys computer use and perhaps would like to make more use of computer technology in science. Tyson does appear to have lost motivation and interest towards science over the primary/secondary interface, and his achievement in science appears to have declined. Tyson would like to become a lawyer when he leaves school, as he did when he was in year six.