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Engaging students in science across the primary secondary interface: listening to the students' voice

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Engaging Students in Science Across the Primary Secondary Interface: Listening to the Students' Voice

Abstract
Most studies indicate primary students' attitudes towards and interest in science decline as they progress into the secondary years. Longitudinal qualitative research exploring this phenomenon is rare as is research which focuses on the students' voice as they cross the interface. In this study multiple qualitative data sources, supported by a 'science interest' composite scale, followed twenty students over two years. In contrast to baseline data on their peers these students, in general, maintained their interest in science. Apart from identifying the teacher's pedagogical approach and classroom environment as two key issues in understanding these students' journeys, the importance of listening to and heeding the students' voice may be an even more critical concern in addressing the decline in students' attitudes and interest in science.

Key words
Attitudes towards science, Interest in science, Primary-secondary transition, students' voice

Students' Attitudes Towards and Interest in Science

Studies across several developed countries have indicated that interest in, or attitudes towards, science declines during the secondary years (Jenkins & Pell, 2006; Lindahl, 2003; Osborne, Simon & Collins, 2003). There is a strong indication that this decline commences at the primary secondary interface (Braund & Driver, 2005; Ferguson & Fraser, 1998) but may even start earlier (Murphy & Beggs, 2003; Pell & Jarvis, 2001). In one major international study Australian (Trends in International Mathematics and Science Study, TIMSS) students were among the least positive in their attitudes (Martin, Mullis, Gonzalez, Gregory, Smith, Chrostowski, Garden & O'Connor, 1999). Retaining student interest in science is important for many reasons, not least of which, is that adequate numbers select science in the senior secondary years (Cleaves, 2005; Lindahl, 2003; Simon, 2000; Simpson & Oliver, 1990) in order to pursue science-related careers. As "scientific literacy is perhaps the driving force of the economy" (Rothaphfel, 2004), this clearly has implications for a nation's growth (Metherell, 2006). As our world and the issues in it, such as environmental and medical issues and problems, are often based on scientific understanding, then it is also becoming increasingly important that more of the community increase in their scientific literacy (Bybee & DeBoer, 1995; Feasey, 2004; Gerber, 2001; Goodrum, Hackling & Rennie, 2001, Millar & Osborne, 1998).

This study centres on students' 'attitudes' towards, and 'interest' in, science. Explanations for why more students are being alienated from science require a refocus on attitudinal research (Ramsden, 1998). Previously there has been a reliance on quantitative data with relatively few studies looking at students' attitudes towards science through "clinical and group interviews"; in fact qualitative studies relying solely on interviews are very rare (Osborne et al., 2003, p.1059). Further, if student attitudes and interest in science are to be better understood, then more complex, sensitive, qualitative and longitudinal studies will need to be undertaken (Jenkins & Pell, 2006, p.50). Also there needs to be more studies to determine students' views of effective teaching (Osborne et al., 2003) in order to address declining interest as well as further research to determine what maintains student 'interest' in science over time (Reiss, 2000). The focus of the study and the research design reported here addresses, at least to some degree, each of these concerns. In particular, this study acknowledges that if student perceptions of pedagogy are a key factor in determining attitudes towards and interest in science then research into why students are losing interest in science across their schooling years and especially the transition needs to access the *students' voice*. Listening to the voice of the students is the significant feature of this research study.

Attitudes and Interest in Science

These two constructs are affective in nature and overlap with constructs such as values, beliefs, opinions, and motivation (Simpson, Koballa, Oliver & Crawley, 1995); cognitive aspects also need to be considered (Ebenezer & Zoller, 1993). 'Attitude' is commonly defined as "a predisposition to respond positively or negatively to things, people, places, events or ideas" and 'attitude to science' as "a person's positive or negative response to the enterprise of science" or put simply "whether a person likes or dislikes science" (Simpson et al., 1995, pp. 212-13). Bagozzi and Burnkrant (as cited in White, 1998, p. 101) envisaged attitudes towards science as “a person’s collection of beliefs about it, and episodes that are associated with it, that are linked with emotional reactions”. White argued that the positive and negative episodes we experience related to science impact on the attitudes we form towards the subject. Investigating attitudes towards science is a complex area.

Studies have suggested that an individual’s attitude to science is made up of a large number of components (Osborne et al., 2003; Simon, 2000). These include “perception of the teacher, anxiety towards the subject, the value of science, self-esteem at science, motivation towards the 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 purposes of this study these variables will be considered in order to gain a more complete picture of a student’s attitude to science and to ascertain whether each student likes or dislikes the subject. It is appreciated that attitudes cannot be directly measured and that it is therefore important to use a range of data sources when we research student attitudes, and to cross check written and verbal responses in order to increase reliability and validity when looking for underlying “trends and patterns” (Ramsden, 1998, pp. 128, 134). This advice has been heeded in this study.

Interest is also a construct that can be conceptualised in different ways and that is difficult to measure (Kobella, 1989; Lindahl, 2003) especially the distinction between “expressed interests” (likes and dislikes) and “manifest interests” (for example hobbies) (Wall, cited in Ramsden, 1998, p. 127). Gardner (as cited in Ramsden, 1998, p.128) devised four questions that probe students’ interest in science: how much students are *interested* in science to meet their personal needs; how much do students *want* to learn about specific issues in science that relate to society in general; how *motivated* are students to carry out academic work in science; and how *willing* are students to follow a career in science or technology? These issues and questions were considered when devising questions for interviews and surveys, and in the carrying out of classroom observations or when analysing and interpreting the data. They are also implicit in the quantitative measure of science interest (Pell & Jarvis, 2001; see later) used to support the qualitative data.

As stated other constructs, such as motivation and self-esteem, overlap with the constructs of ‘attitude’ and ‘interest’ (e.g., Harlen, 2003; Ramsden, 1998; Simon, 2000); further, the relationship between attitudes and interest is not necessarily straight-forward (Simon, 2000). As a consequence of these difficulties, Ramsden (1998) recommended, when carrying out research in this area, that clear definitions of key terms and descriptions of the context underpinning any interpretations be stated. In this study these definitional and interpretation difficulties are acknowledged. Through multiple interviews, numerous observations, and written responses, judgements about twenty students’ attitudes towards science and school science are made: that is whether they like or dislike science and/or school science as Simpson et al. (1995) expressed it. Determinations of their interest in science and school science, whether expressed and manifest, were also made based on how students actively responded to the subject or aspects of it (Kobella, 1989): interest was again determined through multiple and triangulated data sources and seeking information related to questions such as those of Gardner (1985).

School Science and Science in Society

It is important to make a distinction between ‘school science’ and ‘science in general’ (Osborne et al., 2003; Ramsden, 1998; Whitten, Tuck & Haigh 2003). Surveys have shown that students’ attitudes to ‘science in society’ can be positive, albeit with some public disquiet about the applications of science (e.g., Jenkins & Pell, 2006), even though numerous studies have revealed students’ negative attitudes towards ‘school science’ (Osborne et al., 2003) and the majority of students prefer other school subjects to science and this is more significant amongst girls (Jenkins & Pell, 2006). However, some studies have found a substantial correlation between an enthusiasm for school science and science in society (Pell & Jarvis, 2001). When investigating students’ interest in, and attitudes towards, science and school science, these distinctions need to be borne in mind. In this study measures and observations relate to both aspects and are clearly indicated within the text of the discussion.

The Decline in Positive Attitudes and Interest

Causes for this observed decline in student attitudes and interest have been the focus of several research studies and reflective reports. Gender is the most significant factor influencing attitudes to science according to Osborne et al.'s review (2003) and numerous Australian and international studies have found such gender differences particularly during the late primary and early secondary years (e.g., Baird, Gunstone, Penna, Fensham & White, 1990; Ferguson & Fraser, 1998; Jones, Howe & Rua, 2000; Martin et al., 1999; Simpson & Oliver, 1990). A number of studies also have revealed that girls lose interest more so than boys (Hendley, Parkinson, Stables & Tanner, 1995; Simpson & Oliver, 1985; Simpson & Oliver, 1990) or prefer other subjects to science, more so than boys (Colley, Comber & Hargreaves, 1994). This trend has not been universal (Lindahl, 2003; Murphy & Beggs, 2003; Whitten, Tuck, & Haigh, 2003). These gender differences are more than likely intertwined with various curriculum, pedagogical and other variables. These are overviewed next.

A lack of relevance of school science to students' lives is argued to be a strong contributor to declining interest levels (Aikenhead, 1996; Leach, 2002; Osborne & Collins, 2000; Reiss, 2000; Tytler 2007). Many school curricula are "content heavy", often with "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" (Millar & Osborne, 1998, p.3). These curricula leave little time for students to reflect and build on their scientific understanding and cope with science in their daily lives (Goodrum et al., 2001; Murray & Reiss, 2005).

Achievement and/or perceived ability in science probably impact on some students' attitudes towards, and interest in, science (Hasan, 1985; Lindahl, 2003; Osborne et al, 2003). As boys may perceive themselves as having higher abilities in science than girls (Andre, Whigham, Hendrickson & Chambers, 1999; Jovanovic & Steinbach, 1998), then there could be interaction effects between gender and achievement and attitudes towards, and interest in, science.

Teaching quality and classroom experience are very important factors relating to students' attitude to science (Ebenezer & Zoller, 1993; Fraser (1995); Simpson & Oliver, 1990; Woolnough, 1994) and in influencing students' decisions to pursue the subject in senior secondary school (Lindahl, 2003; Woolnough, 1994). Exemplary science teaching has been characterised by: 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 (Fraser, 1995, p. 518). Although the existence of these features is clearly important it is the *students' perceptions* of what is 'engaging pedagogy' that must not be overlooked (Ferguson & Fraser, 1998) in researching attitudes to science. As Fraser's list implies, the relationships between teacher and students is a critical factor and students have voiced this view (Darby, 2005); for example, in Lindahl's (2003, p.14) longitudinal study students saw science teachers as being "very serious" and as one student asked, "Is it not allowed for science teachers to laugh?". Apart from the importance of such relationships within particular primary and secondary science classes their impact on attitudes and interest can be compounded by the change in the types of relationships from primary to secondary school science (Speering & Rennie, 1996).

What bores students and/or what do students dislike about their school science? Students regularly use the word 'boredom' with reference to aspects of school science. It can have many 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 (Baird et al., 1990). This highlights the need for careful interpretation and the use of multiple data sources to discern the underlying factors when this response occurs. Keeping this qualification in mind, various studies would suggest that students dislike excessive note taking in secondary science (Ebenezer & Zoller, 1993; Ferguson & Fraser, 1998; Osborne & Collins, 2000; Speering & Rennie, 1996); learning from the textbook and 'memorizing facts' (Ebenezer & Zoller, 1993, p183; Lindahl, 2003); a dull science laboratory atmosphere (Lindahl, 2003); rushing through the content, including little or no time for practical work or discussing contemporary science issues (Osborne & Collins, 2000); and lessons which "lack demand", although a balance needs to be struck between easy and challenging to achieve an engaging learning environment (Jarman, 1990, p. 22). These non-engaging approaches, by implication, suggest what teachers could consider. Even so, solutions are not necessarily obvious. Practical work, for example, is very popular with students and students preferred it to written work or reading (Cleaves, 2005; Braund & Driver, 2005). However much practical work in secondary science has been more teacher-directed (Fraser, 1995; Goodrum et al., 2001) and this can detract from interest; further Lindahl (2003, p.16) found a lack of understanding of what is expected in science laboratory work or in science generally can lead to students "doubting their own capabilities and losing interest".

Apart from these curriculum and pedagogical factors students' attitudes towards and interest in science can be affected by external influences. Parental perceptions of their children's abilities could be a strong influence in how students perceive their own abilities and this in turn could influence their "expectations for success, achievement, interest in school subjects, and future careers" and this could include parental gender bias towards boys and science (Andre et al., 1999, p. 742; also see Hasan, 1985). The attitude of peers towards science also may impact on an individual's attitudes towards science. Such a 'peer attitude' may increase over the transition and through the middle school years (Talton & Simpson, 1985) and this "synergistic effect" may have a "snow balling effect". If some students become negative (or positive) towards science then others will follow resulting in a "negative group attitude" (or the opposite). In planning this research the influence of peers was taken into consideration during observations and by the use of single-sex focus groups.

A Transition Study Where Attitudes Improved

In a longitudinal transition study in New Zealand, involving a group of female students, significantly more students found science attractive in year 9 (secondary school) than in year 8 (primary school). This positive trend may have been due to teachers of girls-only science classes concentrating on areas and learning styles that appealed to girls, thus forming a positive teacher-student relationship. Other contributing factors may have been: that all units of science included activities to elicit the students' prior knowledge; the wide variety of activities, including a large number of practical science lessons within each unit; that most classes did not copy copious amounts of notes; and "teacher talk (was) limited" (Whitten, Tuck & Haigh, 2003, p. 20).

Research Design

Research Questions and Methodology

This is a "problem-focussed" research study (Wolcott, 1992, p. 7) investigating, especially from the students' perspective, how attitudes towards and interest in science are developed as students progress from primary to secondary school. The research questions were: What are the factors that affect students' attitudes towards and interest in science as they progress from primary to secondary school? In particular what do students say about their attitudes towards and interest in science as they make this transition? In this research question, 'science' can be interpreted as 'school science' or 'science in society'. Most of the collected data refers to school science, although there are instances where student interest clearly is referring to 'science in society'.

To respond to the above research questions an observational case study approach was used, employing participant observation, interviews and a review of documents within a particular setting, here one secondary school and its feeder primary schools (Bogdan & Biklen, 1998; Merriam, 1998). The study was longitudinal in that a small number of students were followed as they moved from year six (primary) to year seven (secondary). The design was influenced by Reiss' (2000) ethnographic study.

Symbolic interactionism was the theoretical framework that underpinned the main methodology (Crotty, 1998) used in the case study; that is, it was assumed that people create their own world and interpret their world in their own unique way. Here it was believed that the way the students define their world determined how they behave in it (Bogdan & Biklen, 1998). The students' voice was paramount. Every effort was made to interpret what the students were saying from their own perspective by taking their views seriously (Crotty, 1998). This study has sought to interpret how the world presents itself to the student (Bogdan & Biklen, 1998; Greene, 1986). Phenomenology therefore defines the main methodology used within the case study. The researchers were 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 crossing from one reality into another there is different meaning for each situation (Greene, 1986 p.496). The researchers were aware of the realities of the "science classroom" and sought to understand how children “make sense” of this quite different world (Aikenhead, 1996 p.3). The phenomenological approach has been reflected in the methods used, with data derived from multiple sources in order to understand how the students interpret their world and hence provide an insight into the students’ attitudes towards, and interest in, science. Supplementing these qualitative data were measurements of science interest (Pell & Jarvis, 2001) as described under ‘data collection’.

Sample

A secondary school into which the students from various feeder primary schools progressed was selected on the basis of proximity and convenience. It was a regional government school in NSW drawing students from a middle socio-economic background. This secondary school choice determined the two primary schools from which the students in the case study were selected. Twenty-one students were selected for this case study. An approximately equal distribution of boys and girls were chosen. In year six, eight students were from an ‘opportunity class’ (for gifted and talented students) and thirteen students were from mixed ability classes. For analysis purposes the twenty students who remained in the study in year seven, were assigned to a ‘high ability’ (5 males; 7 females) or a ‘mixed ability’ (5 males; 3 females) group depending upon the ‘streamed’ science classes to which they were allocated in year seven. Previous studies (see introduction) suggest that sex and ability could influence attitudes towards and interest in science.

Data Collection

Multiple sources were used to collect data about these students in the second half of years six and seven. Individual semi-structured interviews by one of the authors, with a primary and secondary science school background, used preset questions but where appropriate students’ responses were further explored through other question probes, to improve the quality of the data in relation to the research questions. The questions were derived and adapted from various literature sources (see Appendix 1). These responses were supplemented by each case study student’s contributions to a same sex focus group discussion. These groups also included other students known to the case study participants. This approach helps younger students to feel more comfortable and less inhibited in giving responses (Hoppe, Wells, Morrison, Gillmore & Wilsdon, 1995). The questions and interviewing style were similar to the individual interviews (see Appendix 2). The individual and focus group interviews occurred once in each data collection period and were 10-15 and 30-40 minutes long respectively. All interviews and focus groups were audio taped and transcribed. Apart from these interviews all the participants responded in writing to a short survey, which was administered in years six and seven (Appendix 3). Other student data were obtained by observation of their science workbooks and assignments during one of their school terms in each of years six and seven. Although students were asked to keep journals to record their feelings about science, these were only completed during year six.

These participants' interest in science' was also measured using Pell and Jarvis' (2001) attitudinal survey. It contained validated and reliable sub-scales of 'liking school', 'independent investigator' ("a measure of individual investigative science"); 'science enthusiasm' ("feelings about engaging in science at school") 'social context' ("judgement of the worth of science to society as a whole") and 'difficult science' (perceptions of the difficulty of science as a school subject) (pp.854, 56-57). Science enthusiasm was substantially correlated with social context suggesting that students who were enthusiastic about science at school also rated the worth of science in society more highly. Further, the strong inter-correlations between the subscales of 'independent investigator' (9 items, range 9 to 27), 'science enthusiasm' (8, 8 to 24) and 'social context' (8, 8 to 24) were support for "a composite measure of 'science interest' defined by positive attitudes to investigations, (school) science, and its social context" (p.858, parentheses added); this was a 25 item scale (range 25-75) which Pell and Jarvis reported as having a reliability of 0.81 (N=708). For the purposes of analysis in this study science interest scores were 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 eight or more was interpreted as of practical significance as it is 50 percent of the defined interest level ranges. This survey also had two open-ended questions, namely: "a good thing about science' and 'a bad thing about science'. These students' year six survey responses were part of a larger cohort of years five to ten students whose interest in science was measured in a cross-sectional survey reported in Author and Author (2005); their year seven responses, one year later, were also part of a larger sample of year seven students.

Full details of the survey, its content, scales and subscales, and its reliability, as applied to this cohort, are in Author and Author (2005).

Data Analysis

In years six and seven, each student's responses to the various interview and focus group questions and the surveys' open questions were compiled in a table with appropriate headings for each data source. 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 brought "meaning, structure and order to the data" and assisted with the triangulation of data from each data source (Anfara, Brown & Mangione, 2002, p.31). Two narratives were also prepared for each student, when in years six and seven, using the data from each student's table. These assisted in providing a story of *each* student participant's general interests as well as attitudes towards, and interest in, science. The commonalities and differences between students that emerged from the narratives were noted (Anfara et al., 2002, p.31; Glesne & Peshkin, 1992). *Combined* responses, for various groupings according to sex and ability, for example, high ability female students, were also compiled by linking individual students' ideas together (Anfara et al., 2002). This was done for year six and seven responses across data sources (e.g., student interviews, focus groups, written responses and attitudinal surveys). From these combined responses, summary tables of common responses were compiled for these subsets of the participants such as high ability males. These tables also included school year and class groups. Underlying patterns, commonalities and differences across the year groups, ability levels and sexes could then be identified. To overlay on the above individual and group data summaries and narratives, word pictures were compiled to describe each school, class and teaching style, represented in the study.

These data collection methods ensured prolonged engagement with participants and the development of a sense of trust between the researcher and the participants thus increasing the trustworthiness of the data. Further, the multiple data sources and different perspectives, the methods of analysis and the integration of data make the findings more credible as did peer audit of the data and feedback on interim reporting of findings. Full details of the context of the schools, the students and teachers are available as are the various tables so that an audit trail can be followed.

This research design therefore has attempted to address identified weaknesses in previous attitudinal research, namely: poor design of instruments, failure to address areas of validity and reliability; and inappropriate analysis and interpretation of data. It has fulfilled the requirements for qualitative data collection and analysis outlined by Anfara et al. (2002) and was aware of the fallibility of value judgements that are required in such research.

Findings

From these data summaries it was possible to discern how the group as a whole, sub-groups based on sex and ability, and individual students' attitudes towards and interest in science, changed across the primary-secondary divide. Also individuals or groups of students who fell into three science interest categories were identified: those whose interest changed, declined or remained the same. Data for these three groups were analysed to further assist understanding of what was happening across the year six to seven transition.

Science in Society and School Science

When discussing attitudinal and interest changes for these students the data do refer at different times to both school science and science in society. However most of the qualitative data focuses on school science (see interview, focus and survey questions in appendices). Student responses did at times make reference to science in society, and it is clear in the following when this occurred. Pell and Jarvis' (2001) survey included the 'science in society' and 'science enthusiasm' subscales (see earlier); although the latter also includes items related to science in general, Pell and Jarvis align the former with science in society and the latter with school science. Nineteen of these case study students obtained high year six scores on this 'science in society' subscale (>18 of a possible 24). As with the cross-sectional survey (Author and Author, 2005), there was minimal change across the transition, although four students' scores did fall marginally below 19 (Bree, Harry, Tyson and Belinda). These data indicate that perceptions of science in society were positive for these students and that where negative impacts on attitudes and interest are noted, these mainly refer to school science.

Overall Picture Across the Transition Years

At the end of primary school these 21 students were generally enthusiastic and interested in ‘school science’ and ‘science in society’. They displayed interest towards practical science and they especially enjoyed activities where they had the opportunity to design their own experiments, carry out fair tests, and suggest hypotheses. Many of these students were very keen on independent research such as home experiments or researching topics on the internet and in encyclopaedias. Most students were interested in ‘science in society’ topics, particularly environmental, health and space exploration issues.

After the transition these 20 students generally remained positive towards, and interested in, science. Apart from the qualitative data their measured science interest scores did not decline significantly from years six to seven (60.05 to 58.35), whereas for the available samples of non-participant students (year 6, 58.05, n=41; year 7, 53.35, n=29; t-test, $p<0.05$) a significant decline in science interest scores occurred. Further there was a significant difference (t-test, $p<0.05$) between the year seven science interest scores of the participant (58.35) and non-participant students (53.35).

As individuals five students’ interest scores decreased, with one remaining in the high range, three moving from high to medium and one staying in the medium range; one increased while remaining in the high range with 12 scores remaining stable. Hence as individuals these measured interest scores did suggest that differences did occur with about a third of the sample and the qualitative data, in general, were consistent with these measured individual differences in science interest. Table 1 lists the case study students, their sex, assigned ability levels, years six and seven classes, and their year six and seven science interest and attitude subscale scores.

Gender and Ability Group Differences Across the Transition

As a group there were no significant differences in measured science interest scores, for males or females, across years six and seven for the participants (or the non-participants). As individuals 11/20 stated they preferred secondary to primary science: of these four (of 10) were females, three (of 7) of high ability, and seven (of 10) being males, two (of 4) were of high ability. One male, of mixed ability, had a markedly higher secondary science interest score. Three females, two of high ability, but no males, preferred primary science; all were from the same year six class. Two males, one of high ability, and three females, two of high ability had lower science interest scores in year seven. There are suggestions here that secondary science may be of more interest to these participant males and high ability may be of more influence for males.

Students' Voice Across the Transition

Enjoyment of science Students interest was engaged when activities were '*practical*'. In year six, 95 percent (20/21) replied with comments such as 'hands on' science was "fun", "interesting", "fascinating" or "cool"; in year seven, 70 percent (14 [of 20]) 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. During a year six focus group, Leigh, a high ability student said, "Why don't they just do an experiment and have to make you figure it out for yourself? If you see it you understand it more". The students in the same focus group went on to say that they thought experiments were fun and Leigh added "if students are having fun (while they are learning) they will pay attention more".

Other reasons for enjoying science that surfaced were:

- *'Learning new things'*: in year six, by ten students- seven high ability (3/5 males, 4/7 females) and three (of 4) mixed ability females, while in year seven by seven students- four high ability students (two male and two female) and all mixed ability females. No mixed ability males referred to learning new things.
- *Interest in particular science topics:* natural science topics (plants and animals) were mentioned as being popular by five high ability students (3 males, 2 female) from one year six class, and three year seven students of varying ability and sex. Three year seven students thought this topic should access the school grounds more as it was mainly theory and classification tasks. Electricity (five of varying ability and sex in year six and two females of varying ability in year 7) and experiments with explosions and the Bunsen burner were popular in year seven (with both males [5] and females [4]). In general most topics appeared to be liked except year seven physics topics such as light and machines (two boys), possibly due to their perceived difficulty.

- *Enjoyment of questioning and discussion:* Martin's teachers in both years commented on his exceptional knowledge and love of discussing environmental matters. His science interest score remained high over the two years. Ten year seven students (8 of high ability), and all with high science interest scores, were identified by their teachers as students who liked to question and discuss aspects of science.

Dislike of science Students' interest in science waned for several reasons. The most notable was a dislike of *writing and copying of science notes* (year 6- 71% [15/21]; year 7- 100%), yet two year six students liked writing stories, with English, which involves considerable writing, being the favourite subject of seven year six and six year seven students. Other reasons were:

- *A lack of independent research and student-centred learning*: A lack of independent research in secondary school was a disappointment with three year six students from 6H: this had been a feature of their primary experiences. Six year seven female students (three from 7K) also voiced their disappointment in not being able to test their predictions, investigate and carry out fair tests, while three (two from 7K) stated their dislike of being told what was going to happen in an experiment.
- *Perceived increase in the difficulty of science*: In the cross sectional survey (Author and Author, 2005) there was a medium overall negative correlation between the subscales 'difficult science' and 'science interest'. Eleven participant students had increased 'difficult science' scores in year seven. Of these seven (of 12) were high ability students of whom six were from 7K; the other four were of mixed ability. In year six the following appeared to be reasons for science being seen to be difficult: getting information (5 students), electricity and machines (3), and writing, lack of teacher explanations and scientific terms (1 each); in year seven, writing (2), scientific terms, physics, dichotomous keys and a lot to remember (1 each).
- *Insufficient practical science*: This appeared to be related to specific classes and is discussed below.
- *Decreasing use of audiovisual aids and ICT*: Seven (of 20) enjoyed the use of videos and science shows in year seven. Several commented that ICT, including digital and video cameras, could be used as an alternative to writing in science. The use of ICT was less noticeable in year seven compared to year six, especially in 6H.

- *Relevance of 'science in society' and 'school science'*: In both years there was an appreciation of the role of science in society (e.g., making our lives better, it is all around us, helps us solve problems like erosion and create new things, like spaceships). When asked 'why do we do science in school', three categories emerged: for 'life skills and knowledge' (14 in both years; 9 year 7 females); 'for careers' (increase from 4 to 14, 7 year 7 females); and 'unsure' (two in year 6 to 1 in year 7). Year six focus group discussions gave examples of how their school science could relate more to real life and also stated that they would appreciate more excursions. Several of these students' responses implied a discrepancy between science in their classrooms and science in society.

The Impact of Specific Classroom Environments

There were a variety of teaching styles amongst the four year six and the six year seven classes. These reflected, in part, the above distinctions drawn out from the students' voices, that is, emphases on practical science or copying notes and theory. An apparent 'class' and/or 'teaching' effect was detected which was consistent with individual students' voices as well as individual 'science interest' scores. Apart from an alignment with emphases on practical science, copying notes and theory, classes could also be distinguished by the pacing of the lessons, that is whether topics were rushed or not.

Year six Teaching Emphases and Classroom Environments

At the primary level the contrast was between 6H (the high ability class) and the other three classes (6R, 6T and 6S). In 6H there was extensive 'copying' of board notes but also considerable discussion, usually teacher centred but it did include student discussion and debating of topics such as environmental issues. Independent research (using the internet and books and home experiments) accounted for large amounts of time. Students made several power point presentations for science themes. However, they did very little practical science. Of the eight participant students in 6H, seven had high science interest scores in year six. In the other three classes science was a student centred practical experience, where students were encouraged to investigate. Examples of activities included carrying out tests to identify rocks that they had collected (6S), taking part in sensory activities and carrying out tests on mystery liquids to identify them (6T). ‘Copying’ was kept to a minimum. In these three classes nine (of 13) students had high science interest scores.

Year seven Teaching Emphases and Classroom Environments

In secondary school students were distributed amongst all year seven classes and a diversity of teaching styles were apparent. There was a noticeable difference between classes in the amount of practical science experienced and the time spent ‘copying notes’. Most students experienced ‘teacher centred’ science where they followed ‘recipe like’ practical lessons and were often told beforehand the results of experiments. Independent research consisted of a small number of homework projects, usually related to book or internet tasks; all year seven students completed similar tasks.

The classes could be divided into three groups. These were:

- Where relatively more practical activities and opportunities to explore with materials occurred, and there was less copying (7L, 7P and 7S)

In these classes one student Daniel (7S) increased his year six science interest score by more than eight points, while eight of 10 maintained high interest scores. Only Harry’s score dropped by more than eight points but the qualitative data did not appear to support this decrease. One student, Martin, was identified, from the narratives as having an outstanding interest in science in year six. He maintained that interest throughout 7L. Matt and Charlotte, who had high year seven science interest scores, were in 7P which was a large class with behavioural issues. Matt did enjoy secondary science more than primary but found it difficult to concentrate in the noisy environment while Charlotte said she enjoyed primary science more but seemed disinterested at the secondary level apart from the practical activities.

- Where there were fewer practical activities, excessive writing, high expectations, and rushed topics (7K)

Of the seven students in 7K, three (Alec, Tatiana, and Belinda) were amongst those five students whose science interest scores decreased considerably (8 or more) over the transition. Alec did stay in the high interest range as did four others, while Belinda fell to the medium range and Tatiana fell lower in that range (Table 1). From both qualitative and quantitative data, most of these students experienced a decline in their positive attitude towards science. This was a streamed high ability class where there was an extensive amount of ‘copying’ as evidenced in science work books and from classroom observations. All seven students complained about the excessive ‘copying’ both from the board and from textbooks and wanted to do more practical activities. Scientific diagrams and concise report writing were expected to be of a high standard; all participant students had negative written teacher comments regarding their drawings. Tatiana and Anne expressed their frustration with this expectation, while Anne commented on her dislike of expectations with her report writing. Lack of time to complete tasks and rushing through topics were raised by Alana and Anne. Alana and Alec were two of three students who had exceptional interest in science in year six; Alec had the highest year six science interest (73 from a possible 75). Both appeared, from the qualitative data, to lose their ‘spark’ for the subject (also see later- ‘passion for primary science’).

- Where there were limited practical activities due to lack of time and excessive note copying (7H)

The teacher of 7H spent the majority of the lessons talking or writing notes on the board which Clay and Jake (from the primary mixed ability class, 6T) described as “boring”; they displayed disruptive behaviour during such times along with others. Practical activity was usually in the last ten minutes of the lesson and both boys expressed their disappointment and frustration in the limited time for practical activities and would rarely complete their tasks. There was a contrast between these two students. Jake’s attitude to school generally was not very positive and although he became a little more positive towards year seven science this was mainly towards the practical lessons; his ‘science interest’ score remained in the medium range. Clay, a very enthusiastic science student in both years, maintained very high interest scores despite strongly disliking copying and preferring more practical lessons. His teacher described his apparent enthusiasm and desire to discuss aspects of science as “attention seeking, disruptive behaviour”.

These data indicate a consistency between the students’ voice, qualitative observations and their maintenance or decline in ‘science interest’ scores and the various year seven teachers’ different emphases on the use or otherwise of practical science activities, note copying, standards of written work, lesson pacing and behaviour management. Clay was a possible *exception* although his class did still include some practical activities, albeit rushed.

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 student-centred computer research, student prepared 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.

Focus on Specific Students and Groups Of Students

In order to further discern reasons for students changing or maintaining their levels of interest across the transition, participant students were divided into four groups on the basis of various qualitative observations and their ‘science interest’ scores. There is marginal overlap between some of these groups and this is identified in the descriptions.

Students with a Passion for Primary Science and the Transition

In year six 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’ as being extremely passionate about both school science and science in society. Alec and Martin were highly enthusiastic about their home experiments, which they carefully documented in their journals. Their teacher remarked on their exceptional interest for the subject. Alana was also passionate about the subject and said that she loved everything about science; she said “people have done science for so many years and it’s just interesting that school kids can learn about it too”. She spent a great amount of time, which she thoroughly enjoyed, with her father helping him on their farm.

In Year seven, these three students retained high ‘science interest’ scores. Although Martin’s science interest score did slightly decrease in 7L (67 to 63 and mainly related to the Independent Investigator subscale), it was apparent from all the other data that he had maintained a keen interest and enthusiasm towards the subject. This may have been due to his special interest in animals and plants, which were year seven topics. He did not think year seven science was more difficult. In contrast there were real changes with Alec and Alana. Alec’s qualitative data confirmed a deterioration in interest towards school science in 7K; he recorded the largest decrease in science interest scores (by 12 points to 61). Alec’s science interest sub-scores all fell (‘independent investigator’, 27 to 22, ‘science enthusiasm’, 22 to

19, ‘social context’, 24 to 20) although he did not think science was more difficult (Table 1). Alec’s teacher thought he had lost “a bit of interest and zest for science”; despite Alec’s frustration with excessive science writing and lack of independent research, science remained one of his favourite subjects and a science career was still his main goal. Alana’s (7K) ‘science interest’ scores (63 to 59), and subscale scores remained relatively stable over the transition but her qualitative data indicated a declining interest in science. Science, which she preferred in primary school, was no longer one of her favourite subjects. She was now more interested in English, especially drama, physical education and wood technology. Her farm interests, which were science related, had been replaced with more social activities.

Students with Retained or Moved into the High Interest Category

Eight students fell into this category, five boys (3 high ability, 2 mixed ability) and three girls (2 high ability, 1 mixed ability). Six (Roxy, Clay, Matt, Cara, Martin, Alana and Ethen) maintained high interest scores while Bob moved into this category (55 to 59) (Table 1). Alana, as described above, did appear to lose her ‘passion’ for science. Of these eight, four listed science amongst their favourite subjects (Clay, Matt, Ethen and Martin) and four stated that they preferred science in secondary school to primary school (Clay, Matt, Bob and Martin).

Clay (68 to 66), Matt (68 to 67), Bob (55 to 59) and Martin (67 to 63) particularly liked aspects of secondary science involving the use of equipment such as Bunsen burners or things that explode, while Roxy (67 to 67) liked using chemicals and looking at cells through the microscope. Clay, Matt, Bob, Martin, Ethen (61 to 60) and Roxy all liked having more experiments in secondary compared to primary science, but Martin expected even more secondary experiments and Roxy would have preferred more time to continue her experimental work like she had in primary school. Cara (68 to 65) liked experiments and watching videos in secondary school but she particularly disliked the excessive writing and text-oriented work in 7K; classroom observations suggested that Cara was not fascinated with science but she did not appear to have lost interest in science over the transition. Ethen and Martin would have preferred more individual computer research in year seven. Cara and Alana (from 7K) thought secondary science was more difficult and although the others’ science difficulty scores were stable, Matt's (13 [out of 15]) and Bob's (12[out of15]) scores indicate that they perceived science as difficult, rather than easy.

In summary, most of these students appeared to retain their interest in science because of the practical nature of their science activities (6 [of 8]) and their exciting content or unusual equipment (5 [of 8]). This was despite half of these students (4 [of 8]) perceiving year seven science to be difficult rather than easy, with two believing it to be much more so than in primary school. At least two would have preferred more practical tasks or more time on those that they encountered and activities such as watching videos and independently researching science topics. At least one of these high interest students had a strong dislike of writing in science.

Students Whose Science Interest Scores Decreased Markedly

Five students' 'science interest' scores decreased by more than 8 points over the transition, with Alec still retaining a high score, while the others fell or remained in the medium range (Bree, Harry, Tatiana, Belinda). Qualitative data were consistent with these scores. Three were girls (two high ability) and two were boys (one high ability). Alec and Belinda still listed science among their favourite subjects. All these students particularly disliked writing in science and all thought science was more difficult in year seven (see 'difficult science' sub-scores in Table 1). Three (Alec, Belinda, Taitana) preferred more year seven practical work. Bree, in 7R, which had more practical activities, disliked how the teacher directed experiments and being told what was going to happen before carrying out experiments: this was in contrast to her primary experiences where she designed her own (fair test) experiments. Three (Alec, Belinda and Taitana) were in 7K and the other two were in 7R (Bree) and 7S (Harry). Classes 7K and 7S displayed many of these characteristics (see 'year 7 teaching emphases and classroom environments' above).

Students Whose Science Interest Scores Increased

Two mixed ability students (excluding Charlotte), increased 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 subscales both increased by more than ten percent. Although appearing interested in year six science, data gained from interviews, focus groups and observations supported Daniel's increasing interest in science in year seven. He preferred and enjoyed science more as a subject in secondary school, particularly liking practical aspects 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. However, on other occasions, Daniel said he disliked large amounts of science writing. He did not see science as hard or easy in primary or secondary school. Daniel was a little confused between science and geography 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.

Parental Influence

A parental survey when the students were in year six (n=15; 75% response rate for 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. It was not possible to discern any pattern for these students' interest in science and their parents' views as was found by Andre et al. (1999).

Summary of Data Analyses

These case study students as a group generally remained positive towards, and interested in, science, over the transition. This was in contrast to the opposite findings from the cross sectional attitudinal survey administered when these students were in year six (Author and Author, 2005) or with the comparison group of non-participant year seven students. A more detailed analysis of all the case study data appeared to show a decline in interest amongst at least five (of 20) of the participant students.

Irrespective of how the data are analysed two consistent factors have been identified which help in understanding why these particular students liked or disliked science. These are classroom environment and the teachers' pedagogical approaches. The classroom environments that students appeared to 'like' were those where there was more student-centred relevant practical science and more opportunity to explore or investigate and discuss aspects about science during these times, as well as individually researching on the internet. The use of ICT, the outdoors and excursions, were other aspects of science that students enjoyed. The classroom environments that students ‘disliked’ involved copious amounts of note copying, science topics which were rushed, limited practical science and a lack of student decision-making when there was practical work’, and teachers’ written or spoken comments (about students’ opinions, behaviour, or attempts to perform a science task/activity) which sometimes exasperated or humiliated students. Gender and ability did not appear to be a major determinant when determining the attitudes of these students towards science although slight differences were noted: for example, more males said they preferred science in secondary school and only females preferred science in primary school. Also there did not appear to be any association between parental attitudes to science and those of their children, although this cannot be ruled out. Of interest is that up to 15 of these students retained a positive attitude toward, and high interest in, science. This occurred despite the presence of some of the above detracting influences. This is taken up in the following discussion.

Discussion

As indicated numerous attitudinal studies show a decline in positive attitude towards science over the transition years. In contrast to these findings and the cross sectional (Author and Author, 2005) and year seven comparison group surveys, the qualitative and quantitative data found that these students, as a group, remained generally positive towards science, although there were several whose interest did decline across the transition.

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

As these participant students’ science interest scores did not differ significantly across the transition then it is possible there was a “Hawthorne effect” where the participants saw themselves as special because they were chosen as part of this research project and were receiving attention from the researcher (Smith, 2003, p.114). The researcher may have influenced student interest by giving credence to student voice; helping students see the value in school science; and bridging the primary-secondary communication gap.

Giving Credence to Student Voice

Most year six teachers remarked on the high level of enthusiasm of the students towards the study; for example, a number of the 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. 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. They were also aware and appeared very enthusiastic about the fact that some of the findings were to be published. The Relevance Of Science Education (ROSE) study (Jenkins & Pell, 2006) also sought to give students 'a voice'. Listening to students' interests, beliefs and responding to their needs may reduce the 'alienation' towards school that is felt by some students, thus addressing other problems associated with this alienation (Jenkins & Pell, 2006, p.4). Murray & Reiss (2005) also reported on the value of giving students a voice: they were commenting on the findings from a survey designed and implemented by secondary students which were included in a report reviewing Key stage 4 science, by the Parliamentary Select Committee on science and technology in England.

Helping Students See the Value in *School* Science

The majority of participant students (14 [of 20]) saw the relevance of school science and how it related to science in society. Simon (2000, p. 105) identified, amongst other variables that influence an individual's attitude to science, "self-esteem at science, motivation towards the subject and the value of science". Could these students have started to see more clearly the value of science as a result of clarifying their thoughts about the subject and therefore feeling more motivated towards it? Did these students become more confident about their opinions towards the subject as a result of this study and/or did the study enhance their self-esteem towards science?

Bridging the Primary Secondary Communication 'gap'

After the transition 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 transition. 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 transition period. Could the researcher have inadvertently provided a link and communication between primary science and secondary science?

The Hawthorne Effect in this Study

Sometimes intervention as a researcher is unavoidable in a research project (Arnold, 2006). In some research projects the '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 about science and science learning may be a reason why they have retained their interest in science. It suggests that this could be a useful strategy for teachers to try in order to improve students' attitudes towards, and interest in, a science. It is consistent with Hanrahan's (2006a,b) findings about types of classroom interactions, which encourage access to science (see 'teaching quality and classroom pedagogy' below). Although only a small sample these three issues related to the Hawthorne Effect' should not be overlooked as ways of understanding the observed results.

Other Considerations in Understanding the Participants' Science Interest

The students' voice and other qualitative data, together with the survey responses, identified other issues, which impact on whether students like or dislike their school science. These are discussed next.

Teaching Quality and Classroom Pedagogy

In 2000 Australian secondary science classes were dominated by teacher-directed practical lessons and "chalk and talk" style teacher directed theory lessons where students spend time copying notes, listening to the teacher talking or working from a text book (Goodrum, Hackling & Rennie, 2001, p.155). Where primary science was taught in a practical and student centred way and provided opportunities for students to investigate, the result was "high levels of student satisfaction" (p.154). A similar picture emerged in a number of primary and secondary classes in this study.

Teaching quality is one of the key factors impinging on students' attitudes to, and engagement with, science (Ebenezer & Zoller, 1993; Murray & Reiss, 2005; Woolnough, 1994). It can influence students' decisions to pursue the subject in the senior secondary school (Woolnough, 1994). Characteristics of exemplary secondary science teachers were cited earlier (Fraser, 1995; also see Palmer, 1999). Science pedagogical knowledge and a teacher's communication methods (Hanrahan, 2006) and relationships with their students' (Darby, 2005) are critical. White (1988) discussed how a student may experience positive 'episodes' in science lessons with interesting activities that relate to the student and form 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, 2006b, p. 274). 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" (Hanrahan, 2006b, p.278).

The teachers' personalities and pedagogies cannot be overlooked in this case study as being a factor impacting on the students' interest in science. Qualities recognized as being those that promote enjoyment of the subject were lacking in the teachers of 7K and 7H. In 7K students clearly disliked the large amount of teacher-directed theory and copying in contrast to 7L where students remarked on the large number of practical lessons and appreciated having notes printed for them. The high expectations by the 7K teacher and related negative exchanges and comments (about, for example, being exact with scientific drawings and concise with report writing), the heavy use of the text for science theory, unclear explanations, a lack of time for students to thoroughly understand ideas, were all evident. Several of these negative characteristics were also present in 7H, although these students' 'science interest' scores remained stable over the transition.

Practical Science

Generally relevant practical work is very popular with students (Braund and Driver, 2005; Cleaves, 2005; Murray & Reiss, 2005; Palmer, 1999; Whitten, Tuck & Haigh, 2003). The students in this case study are no exception, using words such as 'fun, interesting, fascinating and cool' to describe practical science. Although science practical work does not necessarily lead to improved conceptual learning (Harlen & Wake, 1999), all the students in both years stated they enjoyed practical science or experiments and seven said that they could understand 'things in science' more clearly when they were able to take part in experiments or practical science.

Student-Centred Practical Science

Goodrum, Hackling & Rennie (2001, p. 155) found that in 59 percent of secondary classes students did not choose their own topics or make decisions during investigations. This would detract from students' interest in science (Ebenezer & Zoller 1993). Where such student decisions occurred in primary schools, they were appreciated by the students in this case study. Evidence of these classroom attributes was rare in the secondary classes. Teacher demonstrations and being told the results of an experiment before actually performing the experiment, were practices that were particularly disliked by these students.

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). The use of concept cartoons with puppets suggests that argumentation can engage primary and secondary students and hence retain their interest (Keogh, Naylor & Downing, 2007; Keogh, Naylor, Downing, Maloney & Simon, 2006). In England, the secondary student review of their science curriculum 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"; discussions and debates were rated by these students as one of the most effective teaching and learning methods of science (Murray & Reiss, 2005, p. 92).

In this study, 6H students were given the opportunity to debate and discuss subjects like environmental issues and a number of teachers mentioned during interviews how some participant students liked to question and discuss aspects of science. Several other students enjoyed discussing science topics and issues. However the depth of the discussions and whether they could be labelled scientific argumentation is unclear, but was probably minimal, especially in year seven.

Writing Notes in Science

Whitten, Tuck and Haigh (2003) found female students remained positive towards science over the transition; copying of notes was kept to a minimum in these classes. All Year seven students in this study revealed their dislike of 'writing' in science and a number of students complained about the excessive 'copying of notes'; this was typical of many secondary science classrooms (Goodrum, Hackling & Rennie (2001, p. 155) reported that 61% of students said they 'copied' notes most lessons). Clearly writing is still a central task in science lessons, but students need to see it as writing with a purpose. Hand, Wallace and Yang (2004) have developed a 'science writing heuristic' (SWH) and found its use encouraged teachers to adopt a student-centred approach, where students took more ownership over their practical activities (p. 131) as they were required to think about their hypotheses, observations, claims that they were making, evidence that they were examining, and then read up on their ideas and reflect on how their ideas had changed. Evidence indicated students were more engaged when writing using the SWH.

Narrative writing appears to be an effective method for students to communicate science ideas. Writing a collaborative "mixed genre fictional story" which was published led to year four students feeling "an interactive relationship with the scientific world" and a resultant sense of pride and achievement (Rigano & Ritchie, 2006, p. 13). Both Alana and Clay listed story writing as one of their favourite activities in primary school even though they both disliked science writing. English, which generally requires a large amount of writing, rated very highly as a subject with students in both year six and year seven. Student dislike of writing in science may not be writing per se but 'mindless' copying of notes.

Relevance of School Science and 'Science in Society'

Many students, across various countries, think that school science lacks relevance to their lives (Aikenhead,1996; Osborne & Collins, 2000; Rennie, Goodrum & Hackling, 2001) and are not sure why they are studying it (Lindahl, 2003; Reiss, 2000). This is probably a contributing factor to their current lack of interest in the subject. Issues relevant to 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; Palmer 1999; Tytler 2007).

The students in this case study did think positively about science in society (see earlier). Although one year seven student did not know why there were studying science, most saw the relevance of science in terms of future careers and majority of students, particularly the girls, saw the relevance of science to life. This may help to understand why this group of students generally remained positive and could be linked back to the discussion of the Hawthorne Effect.

Audiovisual and Information Communication Technology (ICT)

Using ICT along with practical and investigative work can lead to a positive experience and enjoyment of primary science (Murphy, 2003). The secondary student review of the science curriculum in England found internet research an enjoyable experience (by 44%) but it was rarely a useful and effective way of learning science (8%) (Murray & Reiss, 2005, p. 86). Several students discussed how they would like an increased use computers and audiovisuals for various purposes in science. A number of high ability students enjoyed independent internet research particularly in primary school and would have preferred more of this research in secondary school. However, they did sometimes note their frustration at not being able to access the information they were seeking. Effective internet use in science is an emerging pedagogical issue (McCrory Wallace, Kupperman & Krajcik 2000; Hoffman, Wu, Krajcik & Solaway 2003); if it is to be used to enhance student interest again student voice needs to be heeded.

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, although 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, although these topics involved large amounts of theory and few practical sessions in most classes. It is acknowledged, though, that reasons for student interest in science topics are complex and may entail various variables apart from gender (Qualter, 1993).

Increasing Difficulty of Science

Students tend to perceive that they have a low ability in science when they find science difficult. This negative perception can influence the students' achievement, attitude and behaviour (Lindahl, 2003). When students perceive they have higher science ability then they have better self-concepts, and therefore are motivated towards achieving (Hasan, 1985). In the cross-sectional attitudinal survey it was found that when science is perceived to be more difficult interest declines (Author & Author, 2005). This correlation is supported, to an extent, in this study as *all* participant students whose science interest scores declined markedly over the transition (Table 1), had an increase in science difficulty sub scores. Sixty one percent of participant students perceived secondary science to be more difficult than primary. There did appear to be some relationship between science difficulty and class effect, as six of the 11 7K students had increased science difficulty sub scores.

The Impact of Gender

Gender, as described earlier, has been implicated as a key factor in 'explaining' attitudinal differences, although there are studies which found that gender was not influential. There were no significant gender differences across the transition in the cross-sectional survey and this included the participant students in the case study (Author & Author, 2005). However the qualitative data indicated possible gender differences in relation to preferred science interest at primary and secondary levels, but again this could be entangled with pedagogical and other effects. More girls (9 [of10]) did see the relevance of science for everyday living than boys (5 [of 10]); and more boys liked experiments involving Bunsen burners, fire and explosions. Only girls commented on the lack of student-centred practical activities in secondary school, such as being able to form their own hypotheses, and only boys referred to the lack of independent research in secondary school.

The impact of Science Ability

Many teachers believe that a student's achievement in science affects his or her attitude towards science (Fraser, cited in Whitten, Tuck & Haigh, 2003). Here there was no significant difference in 'science interest' scores across the transition for students categorised as high or mixed ability. In Year seven there were three (of 11) high and three (of 9) mixed ability students who had medium range 'science interest' scores. There were some responses that differed slightly between the ability groups as more high ability students: stated 'learning new things' as 'a good thing about science' in year seven; could see the relevance of school science 'for life' apart from it being just for career purposes; appeared to have a greater level of understanding of 'science in society'; and may have showed a preference for 'natural science' topics although this could be due to the various topics presented during the data collection period. These findings may be related to some high ability males retaining or increasing their interest across the transition.

Students with a Passion for Science

In year six the students generally were very keen and enthusiastic towards science, but three students were passionate towards the subject. Although all three students maintained a high interest in the subject, only one maintained their exceptional passion over the transition. However, both Alec and Alana, along with the other students from 7K, had a strong dislike of the excessive writing and lack of practical activities. There could be a class effect that may have influenced their attitude to, and interest in, school science. However, other factors such as Alana's social life and her interest in drama may have replaced her love of agricultural science, which could have been a contributing factor to her exceptional passion for both school science and science in society in year six. 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. Students with a passion for science on entry to year seven can be negatively influenced by many factors, not least of which could be their teachers' pedagogical approach.

Response to Research Question

This case study suggests that the following assertions may be made for contexts similar to those described here. Firstly, students' positive attitudes to, and interest in, science across the primary secondary divide, are probably enhanced when they are given a voice related to the teaching and learning of science, have the opportunity to reflect and discuss the relevance of science with others, and there are staff to provide links between primary and secondary science. Secondly, a decline in students' positive attitude towards, and interest in, science, over the transition will probably occur when: (a) teaching quality, classroom pedagogy and environment display several of the characteristics identified earlier such as ineffective relationship and communication skills, lack of student centred practical work, excessive note taking, lack of independent research and limited use of ICT in science lessons; and (b) there is a perceived increase in science difficulty. Thirdly, gender, ability and the attitude of parents need not have a significant influence on students' attitudes towards science.

Summary and Implications for Educators

This is only a small study and the findings cannot be generalised. It is worth noting though that the qualitative data in general were consistent with the quantitative findings, which add further support to Author and Author's (2005) cross-sectional survey report and add credibility to this study. The aim of interpretive studies is to 'understand' what is happening in particular contexts (Neuman, 2000): in this study we now have an increased understanding why these students did or did not change their attitudes towards and interest in school science. Consequently, for school contexts similar to those reported here, important issues have emerged that have implications for science educators.

For the students whose attitudes to science remained relatively stable over the transition, aspects such as the enjoyment of practical science, new content and unusual equipment in secondary school appeared to help maintain positive attitudes. Giving students a voice in science to express their views and opinions, or their likes and dislikes of aspects of science, may have enhanced these students' self esteem in science or enabled them to think more seriously and deeply about the relevance of the subject. The provision of a link and continuity in science over the transition period also is probably an influential factor.

Although the majority of students in this study remained positive to science over the transition, all students voiced their dislike of the excessive note copying. This seemed to be implicated in the responses of the five students whose science interest scores significantly decreased. Lack of student-centred practical work, less opportunities for independent research with the use of computers, a perceived increase in science difficulty and differences in pedagogy and classroom environments in secondary school also seemed important.

The students' voice, in this study, has reinforced and added to the results of the 2000 survey of Australian school science (Goodrum, Hacking & Rennie, 2001). This case study also has provided a rich insight into the school science lives of 20 students and has indicated the multifaceted influences that impinge upon their thinking about science. If students' attitudes to school science are to remain positive it is important that their school science experiences capture and maintain their interest over their schooling years. Listening to the voice of the students regarding their school science and addressing some of the issues arising from 'their voice' could be important steps for science educators towards achieving this outcome.

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Appendices

Appendix 1: Semi-Structured Interview Questions with Individual Students

1. What sort of things do you like to do when you are not at school? (Reis, 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? (Reis, 2000).
5. What do you like about science lessons? (Rennie, Hackling & Goodrum, 1999 [as cited in Goodrum, Hackling and Rennie, 2000, p. 215]).
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, 2000, p. 215]).
9. Why don't you like doing these things?
10. Why do you think you do science in school? (Jo & Song, 2003; Rennie, Hackling & Goodrum,1999, [as cited in Goodrum, Hackling and Rennie, 2000, p. 215]).
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 2: Sample Questions used in focus groups

1) What do you like about science lessons (Rennie, Hackling & Goodrum, 1999 [cited in Goodrum, Hackling and Rennie, 2000, p. 215])?
2) Why do you like doing these things?
3) What don't you like about science lessons (Rennie, Hackling & Goodrum, 1999 [cited in Goodrum, Hackling and Rennie, 2000, p. 215])?
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 3: Short Survey Questions

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, 2000, p. 215]).

Table 1

Case Study Students' Sex, Ability, Class and Scores for Sub-Scales Of 'Independent Investigator' (9 Items), 'Science Enthusiast' (8 Items), Social Context' (8 Items), Difficult Science' (5 Items) and the 'Science Interest' Composite Scale (25 Items) (Pell & Jarvis,2001)

Student	Sx	Ab	I I 04	I I 05	SE 04	SE 05	SC 04	SC 05	DS 04	DS 05	SI 04	Ca 04	SI 05	Ca 05	Dif 04/05	Cl 04	Cl 05
Bree	F	Mi	23	23	16	10	22	17	8	10	61	HI	50	MD	11	6R	7R
Roxy	F	Mi	25	26	20	20	21	21	10	8	67	HI	67	HI	0	6T	7S
*Mayan	F	Mi	17	-	9	-	16	-	8	-	42	MD	-	-	-	6T	-
*Charlotte	F	Mi	18	21	9	15	16	23	7	10	43*	MI	59	HI	-	6T	7P
Clay	M	Mi	27	26	19	16	22	24	7	9	68	HI	66	HI	2	6T	7H
Jake	M	Mi	19	22	12	10	19	20	11	13	50	MD	52	MD	+2	6T	7H
Matt	M	Mi	23	25	22	18	23	24	13	13	68	HI	67	HI	1	6T	7P
Daniel	M	Mi	23	27	13	17	23	24	10	10	59	HI	68	HI	+9	6S	7S
Harry	M	Mi	26	22	14	12	20	16	9	10	60	HI	50	MD	10	6S	7S
Bob	M	Hi	19	23	15	16	21	20	11	12	55	MD	59	HI	+4	6S	7K
Alana	F	Hi	27	25	14	12	22	22	7	12	63	HI	59	HI	4	6S	7K
Tatiana	F	Hi	22	14	8	11	22	19	5	15	52	MD	44	MD	8	6S	7K
Anne	F	Hi	27	23	21	18	22	22	9	6	70	HI	63	HI	7	6S	7K
Ethen	M	Hi	21	23	16	15	24	22	11	10	61	HI	60	HI	1	6H	7L
Alec	M	Hi	27	22	22	19	24	20	9	10	73	HI	61	HI	12	6H	7K
Tyson	M	Hi	22	21	12	11	17	16	9	11	51	MD	48	MD	3	6H	7L
Martin	M	Hi	24	19	20	21	23	23	7	7	67	HI	63	HI	4	6H	7L
Belinda	F	Hi	26	21	17	15	19	17	6	11	62	HI	53	MD	9	6H	7K
*Tia	F	Hi	27	24	-	15	-	19	-	10	-	-	58	HI	-	6H	7L
Cara	F	Hi	25	25	21	19	22	21	5	11	68	HI	65	HI	3	6H	7K
Leigh	F	Hi	27	11	15	12	20	21	12	10	62	HI	55	HI	7	6H	7L

Notes Sx= Sex, Ab=Ability (Mi = mixed, Hi = High), II= 'Independent Investigator', SE= 'Science Enthusiasm', SC='Social Context', DS= 'Difficult Science', SI= 'Science interest', Ca= Science Interest categories: low (LO) (25-42), medium (MD) (42-57), or high (HI) (58-75), Dif= difference between 'science interest' scores between 2004 and 2005, Cl=Class.

*Mayan did not continue at the secondary school throughout year seven. Charlotte's attitudinal survey results appeared to very similar to 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's attitudinal survey was incomplete in year six therefore her SI score was unable to be calculated.