School Culture and Attitudes to Science

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Abstract

This study investigated possible relationships between school culture and attitudes to science held by teachers and students.

It was a single site case study situated in an Intermediate school, in a middle class suburb of Auckland's North Shore.

It describes how the school has chosen to solve its science delivery problems by setting up a system of prepared science lessons in addition to participating in a science fair and science badge scheme. The values underpinning the school science culture were seen to be: a predominately traditional approach to science, strong leadership, an emphasis on outside schemes and competition.

Teachers had a generally positive attitude to science teaching but expressed both positive and negative sentiments regarding science support in the school. They felt they would have more confidence if their knowledge of science content increased.

Students also had a generally positive attitude to science. Boys, Asian students and form one students scored more highly on curiosity towards and positive image of science than girls, European students and form two students respectively. Students indicated they enjoyed challenging, hands-on science, where they were active both mentally and physically.

The study concludes by proposing two models which draw links between the culture of science in the school and attitudes to science.

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Chapter One
Introduction

The culture of a group can be defined as "A pattern of shared basic assumptions that the group has learned as it solved its problems of external adaptation and internal integration, that has worked well enough to be considered valid and, therefore, to be taught to new members as the correct way to perceive, think and feel in relation to those problems" (Schein, 1992, Pg 12).

This study examines how one school, in attempting to solve its science organisational and teaching problems, has built a culture of science in the school. Following a description of the culture, this study then examines any relationships there may be between attitude to science and the culture of science in the school.

In this chapter, background in the topic will be outlined followed by the aim of the study. The research method informing the research will be articulated. Finally an outline of the thesis will be provided.

1.1 Background

Concern has been expressed in New Zealand over a number of years regarding low levels of scientific interest and literacy among the general public. A 1991 Ministry of Research Science and Technology study of 1,012 adults revealed that:

- "Fully 90 per cent were scientifically illiterate, having less than a minimum understanding of the processes terms and social impact of science.
- Only 13 per cent were even attentive or interested in science, with an even smaller percentage of women in the sample being interested.
- Only 3 per cent were both literate and interested; that is most of the 10 per cent who were scientifically literate, were not interested in science!
- Overall there was a negative attitude to science." (MORST, 1991, Pg 4).

While the Ministry's definitions and measures of 'literacy' may be questioned, the report indicates the level of government concern and the need for further investigation.

Reports prepared by the Organisation of Economic Development (OECD) countries reveal that New Zealand ranks fifteenth out of eighteen OECD countries for producing non-university science graduates (125 graduates out of 100,000 persons in the labour force aged 35 to 34 years. (OECD, 1996)) In addition New Zealand ranks ninth out of twenty five OECD countries for producing university level graduates (816 graduates from 100,000 persons.) While this may appear more positive, the OECD country mean is 744.8 graduates and New Zealand is only slightly over that at 816.5 university level science graduates. This lack of scientific training is of concern as "scientific competence is vital for the future of scientific, medical, industrial and technical work and research in New Zealand. It is important to enable citizens to understand, appreciate and make informed decisions about the technological world in which they live." (Matthews, 1995, Pg 19).

The middle school period has been identified as a 'nodal point' when attitude towards science can be optimised (Gallagher, 1994). Simpson and Oliver, (1990) have identified this stage as one where attitude and motivation towards science combines with achievement in initial required science courses to produce 'science self-concept', which is predictive of participation in elective science courses in high school. Due to this, the intermediate school level was chosen for this study.

While many factors have been examined in regard to negative and positive attitudes towards science and its uptake, the more recent call has been to broaden the scope of the research to include the way in which schools implement science. Harlen (1992) argues that "Surveys of policies and performances describe the picture of provision and effects at national levels and research into pupils' ideas has shed some light on the learning of individual pupils. Between these extremes, however, at the levels of school and class planning and of teacher-pupil interaction, very little so far has been done" (Pg 501). It is therefore the aim of this research to examine possible relationships between the culture of science in a school and teachers and students attitudes to science. In doing this, the intended science curriculum, the implemented science curriculum and the attained curriculum, in terms of attitudes gained, will be examined. A useful model to depict the concepts of intended, implemented and attained curriculum was developed by Robitaille et al (1993) and is presented in figure 1.1 over.

1.2 Research Method

In order to examine these curricula and their interactions in relation to culture, an in depth single site case study will be conducted.

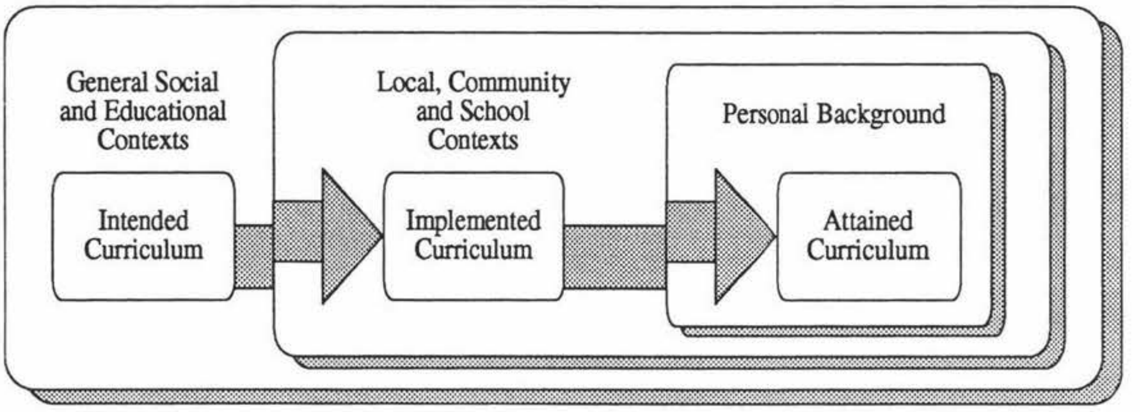
The intended science curriculum is fixed by the educational authorities and will be examined by analysis of the science curriculum content and methods of teaching suggested.

The implemented curriculum concerns the way in which curriculum is interpreted in individual schools and classrooms. The school science scheme will be analysed as will teachers' self-reports on science teaching practice. The school context of science or the culture of science, which could potentially influence implemented science curriculum will also be described through document analysis. The nature of community support for schooling also influences implemented curriculum and will be described.

The attained curriculum, or students' attitudes to science is likely to be affected by their background characteristics such as gender, age and ethnicity. Their attitudes to science will be ascertained by attitude inventories, an open response section and focus group interviews.

Figure 1.1

Intended, implemented and attained curriculum.



Source: Robitaille et al (1993).

Having described the culture of science in the school including the students' and teachers' attitudes to science, it is the aim of this study to investigate possible relationships between the culture of science in the school and attitudes to science.

1.3 Outline of Thesis

This research is arranged in nine chapters with accompanying appendices.
The background and related literature are the feature of Chapter two, culminating in the research questions. The methodology employed in undertaking this research is outlined in detail in Chapter three. Chapters four to seven summarise the results from this study. Chapter four presents the results describing the culture in order to provide the reader with a background in which to set the remaining results. In Chapter five, results describing teacher perspectives are presented and in chapter six results describing student perspectives. Chapter seven describes the values underpinning the culture of science in the school and how they relate to the students' and teachers' attitudes to science. Chapter eight discusses these findings with regard to the literature and Chapter nine summarises the answers to the research questions and suggests direction for future research.

Chapter Two
Literature Review

In this chapter the literature backgrounding this study will be discussed. Initially the reasons for interest and concern regarding uptake of science will be outlined followed by investigation of the link between uptake and attitudes to science. The nature and structure of 'attitude' and 'student attitude' to science will be examined as well as factors affecting attitude. The nature of and factors affecting 'teacher attitude' to science will also be examined. How the context of the school environment may affect attitude will also be discussed. Finally arguments calling for a broader socio-cultural focus to studies of attitude lead to a discussion of school culture and the proposition that their may be relationships between the culture of science in the school and teachers' and students' attitudes to science.

Literature reviewed in this chapter comes from western countries, North America, Europe, and Australia and therefore has relevance for this study. New Zealand literature will be specified as such.

2.1 Uptake of Science

Uptake of science, when it becomes an optional school subject and later at tertiary level, is an area for both interest and concern. It is an area of interest as it is seen as influenced by a myriad of factors. The student's experience of science in school with its resultant attitudes and achievement can predict science persistence in future years. Gallagher (1994) posits that emphasis on enquiry-based instruction and science process skills have a strong predictive value on the middle school student's later uptake of science. Parental attitudes towards science and education can also influence how science activity is received in the home. Solomon's (1994) investigation into science activities in the home revealed how the culture of the home accepted or modified science activities. Parental aspirations were viewed as having large effects on their children's achievements. Community views of science can also impact on the uptake of science. In studying a rural community, Charron (1991b) noted how the students' low evaluation of the relevance of science to their lives was matched by the adults in the community. She argued that this community based opinion was understandable as there were only three jobs in their community which required scientific skill.

In addition to the uptake of science being an area of interest, it also has been an area of concern. There have been a series of reports in New Zealand outlining concern for lack of uptake of science when it becomes an optional subject at secondary school. There are various reasons for this concern. Burns (1984) argues that "if students do not choose to study science there is little likelihood that they will leave school with a sufficient understanding of their world, either for their own wellbeing or to be able to vote responsibly on scientific and technological issues" (Pg 14). An alternative to this aim for individual empowerment, is the argument for more scientists to work in industry to enhance New Zealand's economic performance. The Ministerial working party on Science and Technology (Beattie, 1986) stated that New Zealand needed to produce "more scientists, engineers and technicians and more people who are technically literate and numerate, to provide the overall weight of effort for these (knowledge based) industries" (Pg 109). Whatever the motivation for concern, the paucity of students taking science when it becomes an optional subject has been reported in pessimistic tones from 1984 to 1992.

Burns (1984) expressed concern, when reviewing the percentages of students enrolled in sixth form subjects, at the decline in numbers taking chemistry and physics from 1964 to 1984. She argued that it would mean that only 15% of the population would ever study physics or chemistry as separate disciplines. A report for the Royal Society of New Zealand on science education by Clark and Vere-Jones (1987) also reveals declining enrolments in physics and chemistry and emphasises the gendered nature of subject choice with girls preferring biology over maths and the opposite being true for the boys. They contend that the most disturbing trend "is the generally declining proportion of males enrolling in physics and chemistry and the lack of any substantial compensating increases in the proportion of girls taking these subjects" (Pg 20). The Report of the Ministerial Task Group Reviewing Science and Technology Education (1992) argued that by 1990 there had been an increase in the number of students taking English, maths and commercial subjects, but very little growth in students taking science subjects. As the data pertaining to participation in various sixth form subjects from 1971-1990 presented in this report is displayed in bands, 1971-1975, 1976-1980, much information is lost in the averaging process. Therefore data for discrete years were accessed (Education Statistics of New Zealand, annually).

Data showing the percentage of male and female sixth and seventh form students who took biology, chemistry and physics in the years 1980 to 1996, are presented in Tables 2.1 and 2.2 over. The percentages were calculated from the total sixth and seventh form population of each year respectively. Table 2.1 shows the percentage of students taking any of these three science subjects has dropped since in 1980's, particularly when compared with the early 1980's. The steadiest level of participation are levels of female participation in physics, but these were not high even in the early 1980's. Gender differences have become smaller between males and females electing to study biology, chemistry and physics but this appears to a be a result of declining numbers of males electing to study these subjects rather than more females taking them.

Table 2.1

Percentage of sixth form students taking biology, chemistry or physics by gender.

Year	Biology		Chemistry		Physics	
	Male	Female	Male	Female	Male	Female
1980	48.71	72.07	36.62	25.11	49.00	15.39
1981	47.76	69.61	36.96	25.00	48.57	15.57
1982	46.26	66.13	35.87	25.55	47.74	15.90
1983	44.14	63.64	33.16	25.25	45.19	15.32
1984	43.31	63.91	34.00	27.37	46.67	16.96
1985	42.36	63.98	34.81	28.79	48.63	17.38
1986	34.35	53.81	30.71	26.07	45.26	16.73
1987	29.74	48.40	27.47	23.40	43.16	15.65
1988	27.60	44.40	26.47	22.45	42.08	15.99
1989	26.84	40.51	24.75	20.78	39.82	15.25
1990	25.88	39.76	23.48	19.75	37.51	13.97
1991	25.59	38.83	22.16	19.33	37.18	14.47
1992	27.77	40.33	23.29	20.92	34.23	14.16
1993	32.58	44.60	27.59	23.11	37.04	15.40
1994	29.33	42.20	25.62	23.57	34.57	15.33
1995	29.40	41.88	25.61	23.63	35.70	16.84
1996	23.91	34.01	21.37	19.50	29.44	13.71

- ***Data taken from Education Statistics of New Zealand, (Department of Education) editions 1980 to 1996.***

Table 2.2

Percentage of seventh form students taking biology, chemistry or physics by gender.

Year	Biology		Chemistry		Physics	
	Male	Female	Male	Female	Male	Female
1980	47.50	64.70	54.02	36.48	56.20	19.70
1981	45.23	63.89	52.05	38.12	55.80	22.80
1982	43.29	64.34	52.15	38.53	55.16	24.02
1983	42.06	60.08	48.95	36.80	54.01	22.08
1984	40.62	59.71	47.70	36.89	51.49	22.13
1985	39.09	59.00	47.48	39.85	52.04	23.48
1986	36.45	55.11	36.00	35.31	50.05	20.87
1987	34.19	48.98	38.40	30.12	44.16	17.86
1988	31.19	48.10	34.21	26.68	43.58	16.18
1989	30.82	45.55	31.11	25.28	41.53	15.82
1990	29.65	43.30	29.63	21.39	39.36	13.18
1991	28.62	40.14	27.64	19.20	36.94	13.06
1992	30.95	41.57	28.48	20.62	36.94	13.74
1993	27.81	37.46	25.79	18.86	33.75	13.02
1994	32.97	42.70	29.43	21.95	37.60	14.38
1995	32.78	43.14	30.42	23.35	38.11	15.37
1996	30.64	37.09	26.43	20.15	30.95	13.85

• ***Data taken from Education Statistics of New Zealand, (Department of Education) editions 1980 to 1996.***

Table 2.2 shows that participation rates in biology, chemistry and physics for seventh formers have also fallen as well as smaller gender gaps in participation. This could also be explained by declining male uptake of science, rather than increasing female uptake.

Therefore there is concern regarding New Zealand students' uptake of science when it becomes an optional subject at school. An avenue which some have regarded as useful for improving uptake of science, is that of enhancing attitude to science. Burns (1984) argues that student attitudes to science influence their subject choice, a view echoed by Myers and Fouts (1992) who state "students with a positive attitude towards a subject are more likely to want to extend their learning in that field, both formally and informally, after the direct influence of the teacher has ended" (Pg 929). Gallagher (1994) is more specific in arguing for the middle school as a "nodal point" (Pg 722) during which students' interest in science can be enhanced and that this "may have a substantive effect on how far students choose to pursue science in school" (Pg 733). Therefore if attitude is important to uptake of science, it is crucial to examine the structure of attitude.

2.2 Attitude and Attitude to Science

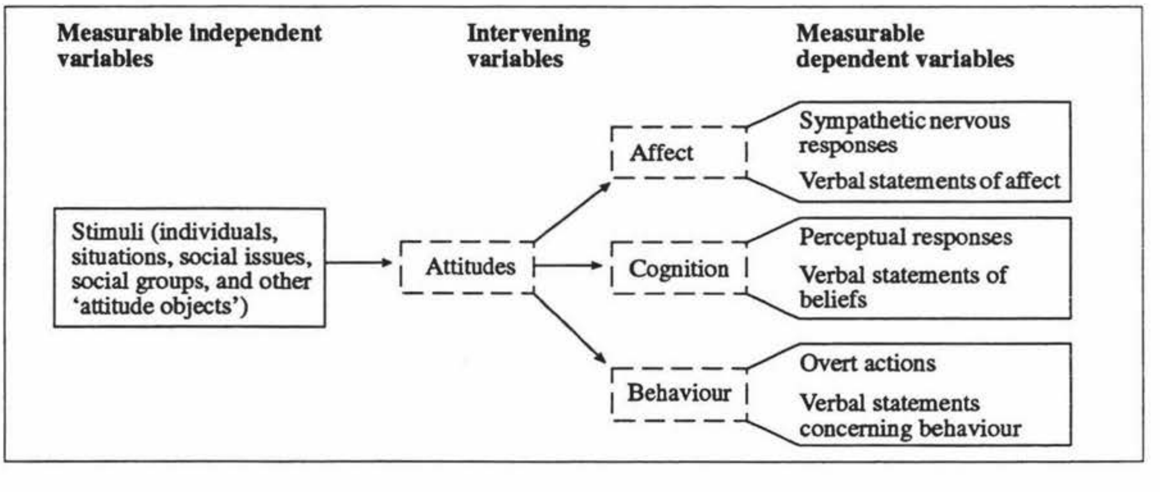
An attitude has been described as "a relatively enduring organisation of beliefs, feelings and behavioural tendencies toward socially significant objects, groups, events or symbols. A general feeling or evaluation - positive or negative - about some person, object or issue" (Pg 72, Vaughan & Hogg, 1995).

Contemporary social psychology texts point to two central arguments in the debate over the structure of attitude; the three component or tripartite model and the unidimensional model.

Rosenberg and Hovland (1960) proposed a three component model of attitude which included affect (concerned with feelings and emotions), cognition (concerned with beliefs) and behaviour (concerned with intentions to act).

Figure 2.1

Rosenberg and Hovland's model of attitude.



Therefore attitude, in this model, is a construct that intervenes between antecedent stimuli and subsequent behaviour.

However, Tesser (1995) argues that more recent research has emphasised that attitudes can be based on just one or two of these components, called a unidimensional model. Therefore some attitudes could be based on how the object makes one feel, whereas some attitudes could be based on how the object makes one think. He also argues that while early research on the three component model emphasised the consistency and correlations between all three components, more recent research has emphasised that either the affective or cognitive bases of attitude may be more important, depending on the attitude object. Unidimensional models do not include a behavioural component or disposition.

Stahlberg et al. (1988) argue that evidence in support of unidimensional or multidimensional models "thus far must be considered contradictory" (Pg 145). However, they state that in most practical research scales using the unidimensional concept are preferred because they can be measured more simply.

With regard to research on attitude to science, Rennie and Punch (1991) have adopted the three component model of attitude. They argue that "science related affect not only encompasses the evaluative and emotional reactions of the student's like or dislike, interest or disinterest in school science, but also includes certain perceptions and beliefs the student has about science, and thus involves a cognitive component. Furthermore, the student's enthusiasm or willingness to be involved in science lessons contains a behavioural component or predisposition to act in certain ways towards school science" (Pg 196).

2.2.1 Characteristics of student attitude to science

Regardless of the model of attitude employed in the research, however, student attitude to science demonstrates two main characteristics. There is a decline in positive attitude towards science as students progress through the school system and students hold varying attitudes toward different branches of science rather than one point of view of the subject as a whole. This last characteristic tends to be influenced by gender.

Yager and Yager (1985) found that students rate science as less fun and less exciting the longer they stay at school. In a longitudinal study conducted over ten years Simpson and oliver (1990) found that attitude to science dropped each year between grades six and ten with the greatest drop occurring between the beginning and middle of the year. The overall attitude to science at the end of grade ten was found to be near neutral. Baker

(1992) found, when triangulating both qualitative and quantitative data from students in grades two, five, eight and eleven that the students in grades two and five had the most positive attitude with those in the eighth grade having the most negative attitude towards science.

In New Zealand, the National Educational Monitoring Project of science (Crooks and Flockton, 1995), measured attitude at Year 4 (standard two) and Year 8 (form two). The data gathered mirrors the international trends with 60 percent of year 4 students using the most positive rating on the question relating to enjoyment of science at school, but only 33 per cent of year 8 students giving the most positive rating for this item. This fall in positive attitude to science mirrored a fall in perception of ability in science. On the question 'how good do you think you are in science?", 25 per cent of the year 4 students chose the top rating compared with 10 per cent of the year 8 students.

Therefore it appears that students become less positive about science, the further they advance through the school system. Studies have also shown that students have differing attitudes to the various branches of science and not just to science as a single subject. In Smail and Kelly's (1984) study of gender differences in attitudes to science, factor analysis revealed that girls had more positive attitudes to studies of nature and the human body, whereas boys had more positive attitudes to physical sciences. This also points to one of the factors affecting student attitude to science, that of gender.

In addition to two main characteristics of attitude to science, there are particular attitudes which the literature refers to. Science is referred to by students as being easy or difficult, boring or interesting.

Hendley et al (1995) suggest that a factor which has emerged from the literature as negatively influencing attitude as students become older is the perception that science becomes more abstract and difficult as students move through school. Keys (1987) found that older students perceived science as harder. In a study of students in England she found that 35 per cent of ten year olds agreed that science was a difficult subject, compared to 51 per cent of fourteen year olds. Thirty five per cent of ten year olds agreed that there were too many facts to learn in science compared with 50 percent of fourteen year olds. The New Zealand results from the Third International Maths and Science Study (Chamberlain, 1995) reflect this also. On the item "science is an easy subject", 52 per cent of standard two and three students surveyed for the study agreed or strongly agreed, compared with 33 percent for form two and three students.

Science which students describe as interesting often involves hands-on experiments.

When Wasserstein (1995) asked middle school students what their most memorable schoolwork was, the majority answered hands-on science experiments because they enjoyed the challenge and felt it was meaningful. Meyer and Carlisle (1996) in studying grade 4 and 7 students carrying out experiments have concluded that students at both of these levels are capable of conducting experiments and should have chances to do as part of their science education. Martinez and Haertel (1991) have developed a model of three components to include in interesting science experiments for middle school students. They term this the model of 'intrinsic interest'. They contend that experiments should be cognitively challenging, so that they are likely to engage the student, where possible manipulation of equipment also enhances the experience. Finally a social element of completing an experiment with others is the third element of an interesting experiment. Sheppardson and Pizzini (1993) found that students prefer to establish their own learning activities. They compared three instructional approaches to teaching science: lecture-worksheet, traditional laboratory and problem solving. The problem solving was perceived as having more student 'ownership' than the first two options. In form two classrooms in New Zealand, 'almost always and pretty often' 70 percent of students copy notes from the in pairs and small groups, 60 per cent do an investigation or experiment themselves and 56 percent have a teacher give a demonstration of an experiment (Garden, 1996). The authors suggest that "worthy of note are the significant proportions of students who report infrequently or never being involved in experimental or practical work" (Pg 165).

In New Zealand, in 1987 the Learning in Science Project team presented a report (Stead, et al.) on attitudes to science in form one to four New Zealand students. They reported that many pupils preferred practical work to writing, although some did not like equipment and chemicals, girls preferred biological topics whilst boys liked physical and chemistry based topics, there were big differences observed between Polynesian and Europeans, and they found that younger students appeared more positive toward science. Teacher enthusiasm was seen as important for fostering a positive student attitude to science, and both pupils and teachers related positive attitudes to being successful in the classroom and to good management and control. They also reported that pupils are more likely to have an interest in science if they see its relevance.

2.3 Factors Affecting Student Attitude To Science

There are many factors which affect student attitude to science. The home environment and any extra curricular science activities encouraged within it, the student's gender, the teacher's attitude to and ability in science, teacher practice of science teaching, the nature of classroom and school environment and finally student achievement.

2.3.1 Parents' attitude to science

Tytler (1992) noted when studying students pursuing independent research projects that the school and teachers had little influence on the topic chosen or the completion of the project, but that most of the help and encouragement came from within the home environment. Woolnough (1994) has noted that the pursuit of these extra curricular science activities can predict science uptake in later life. In addition, he found that students who pursue higher education in science or engineering have been affected by a scientific home background. This was particularly the case with students electing to study physics, 53 per cent of whom having had one of their parents study science or engineering.

The parental interaction discussed by Tytler (1992) raises interesting questions regarding parents' differing abilities and motivations to provide such support. Nash (1993) would argue, using a Bordieuan analysis and data from studying family resources and access to education in New Zealand, that such parents are passing their 'cultural capital' onto their children and ensuring their success within the system. In Nash's (1993) study parents argued that their most important contribution was support and encouragement followed by wealth and involvement with the school.

Also illuminating in relation to science and home culture, a study by Solomon (1994), mentioned previously examined the culture of the home and the reception of primary science activities brought into that environment. She found that the nature of each home culture examined affected the way the science investigation was accepted and then modified by the parent: "the items will be tailored to fit the home culture during their reception and thus will themselves be changed in the process. In this sense the science activity sheet was modified by even the tone of voice in which the parent read it aloud and how she encouraged the child during the investigation" (Pg 575). Solomon (1994) does not subscribe to the position that middle class homes necessarily produce children with an educational advantage, as an analysis from Bourdieu's perspective would suggest. Instead she prefers Geertz's theory of culture, where culture is likened to a web of significance and shared meanings which each person spins. Solomon (1994) argues that "an understanding of the power of a home culture to imprint its own values and meanings on messages from the outside world .... it casts light on how parents' aspirations produce substantial and varying effects on school achievement. Working class and middle class homes produce their own range of cultures which are local and familial. Each one will reflect general values relating to love, recreation, order, work, technology etc. And education cannot fail to be included in this" (Pg 576). However, one could argue that families whose 'webs of significance' match the values rewarded by the education system will be more easily assimilated into that system.

When Germann (1994) tested a statistical model to measure the contributing factors to science process skills acquisition, he measured a weak relationship of .24 correlation between attitude toward science in school and parental education level. However, he also points out that when more qualitative data, rather than quantitative data is gathered to provide a profile of what parents actually do in the home to support the education of their children, then correlations can increase to between .50 and .80. Although Solomon was examining parental education in and attitudes to science, not general educational level, Germann's (1994) findings supports Solomon's research regarding the importance of the way parents interact with their child at home around learning activities in terms of building positive attitude to science.

Therefore, parents have been found to have important influence in developing their child's attitude to science, by role-modelling the importance of science, by interacting positively around science activities and by providing tangible assistance with science projects.

2.3.2 Gender

Weinburgh (1995) conducted a meta-analysis of literature from 1970 to 1991 on gender differences in student attitude towards science and concluded that in general boys do have a more positive attitude towards science than girls, but if specific disciplines are examined, the magnitude of the effect changes. Specifically, girls have more positive attitudes towards biology and boys towards chemistry and physics. The differences between boys' and girls' attitudes to science, Harding (1986) has argued, have their foundations in early socialisation and continue to be reinforced through school learning experiences and the influence of self-image. Finally gender's influence on attitudes to science is manifest in career choice.

Brown (1993) argues that girls are prevented by their early socialisation from building up confidence in science because girls do not receive positive reinforcement for exploring their surroundings. They instead tend to be held close and pacified "so boys as toddlers roam further afield, get dirtier and encounter a wider range of objects and materials as a consequence, building up experience of shape, size, weight, texture and other properties of things in the world around them" (Pg 65).

Chodorow (in Harding, 1986) uses object relations theory to argue that there are different 'ways of knowing' associated with masculinity and femininity. Both sexes are usually raised by a female caregiver. The girl therefore, is brought up with a similar creature and grows up embedded, connected with a framework of relating to people. The boys grows up "unconnected, separate and expecting to negotiate from a position of otherness, even of conflict" (Pg 122). Grant (in Harding, 1986) concluded from a study of 14 year old entrants in a national design competition, that although the boys and girls worked on similar devices, the boys saw the problem in the device. The girls, however, saw the problem in the social context and the technology was a way of solving the problem. These socialised 'ways of knowing' manifest themselves, as Weinreich-Haste (1986) put it in "differences in how scientific activity is conceived and how the products of science and technology are evaluated" (Pg 123).

Boys' and girls' experiences whilst learning science at school also impact differently on attitudes to science. Text books and interactions during lessons are two areas where boys and girls are subject to different experiences. Kelly (1987) cites examples of illustrations in text books where girls are either not featured or are featured looking puzzled or doing 'silly things'. During the Girls into Science and Technology Project (GIST) (Whyte, 1986), which involved eleven year olds, at the form one level, it was observed that most of the science teaching staff in the study were male and the lessons tended to be taken from a masculine context. The boys took up more of the teacher's time and dominated discussions. During a study of girls' interactions with teachers in mixed physics classes, Taber (1992) found that boys received more 'public' interactions concerning the cognitive content of their physics lessons than the girls. This was because they called out their answers, rather than the teacher initiating more interactions with the boys. However, this still meant that by the girls conforming and not calling out, they were missing out. Staberg (1994) when researching grade 7 to 9 girls and boys actions and thoughts about science also found that girls tend to conform in science lessons and try to minimise disruption in the lesson. Like Whyte and Taber, Staberg also found that the boys dominate the public arena. Like Taber she observed boys freely calling out comments and the teacher giving these boys attention in order to avoid chaos.

In contrast to findings which argue a difference in classroom behaviours between girls and boys, Hacker's (1991) investigation of science lesson behaviours did not support the hypothesis that gender differences in science achievement was a result of differential treatment of boys and girls in science classes. However, his sample group of fifteen year olds was comprised of only twelve students, and do not lend themselves for wide generalisation.

Gender has been argued to affect both subject likes and dislikes within science and also preferences for certain process skills or activities. Smail and Kelly (1984) found during the GIST study, that boys were much keener to learn about physical science and girls were much keener to learn about nature study and human biology. Girls had more experience of biological science activities and boys had more experience of construction activities. Taber (1992) has also identified gender differences previously reported in the literature. He surveyed pupils in their first weeks of secondary school to see what topics they would be interested in studying at school. Boys mainly selected topics related to mechanical science and girls selected topics related to human biology.

The types of activities which appeal to students in science are also affected by gender. Staberg (1994) found that girls prefer knowledge connected with their own and others' lives while boys prefer playing with equipment and making things. Girls prefer to collaborate and work together, whilst boys prefer to compete. Staberg argues that the girls' learning style could be characterised as 'work', whilst that of the boys could be described as 'play'. Baker and Leary (1995) also found in talking to girls in grades 2,5,8 and 11 that they preferred to learn science in an interactive setting rather than completing activities which isolated them such as reading, writing or note taking. They noted that "when girls expressed positive sentiments about school science it was because it met their needs for relationship and connection. Good teachers really communicate and group work lets you work with your friends. Independent work separates and isolates and decontextualised topics are uninteresting" (Pg 14).
Also linked with the influence of gender on the school experience of science is the timetabling of optional subjects at senior school level. Fuller (1991) has noted how science tends to be timetabled against more traditionally female areas such as foreign languages and human biology, which, according to those girls interviewed, could hinder girls from choosing science.

The body of literature pertaining to female self-image and how this can interact with and influence attitude to science is also informative. Staberg (1994) and Kelly (1988) have written and researched self-image with regard to attitude to science. At the same time as Smail and Kelly (1984) administered their first inventories to measure attitudes to science, the students also completed tests measuring cognitive skills, sex stereotypes and general background information. The same battery of tests were repeated two and a half years later. Kelly (1988) examined the relationship between sex stereotyping inventories and the attitude to science inventory over two and a half years from when the students were 11 years of age to 13 years of age. Kelly (1988) found that "Girls who saw themselves as feminine were more likely than other girls to see science as more suitable for boys than for girls and to see differences in the suitability of various occupation s for girls and boys. The reverse was true for girls who saw themselves as masculine" (Pg 156). She also concluded that girls who were more able, on average, were less stereotyped and less likely to see science as masculine and had less feminine self-image than the less able girls. Girls who saw themselves as feminine were less likely to choose physics with the reverse being true for those girls who saw themselves as masculine. Introducing an additional perspective to the gender debate is Staberg (1994) who suggests that differing levels of maturity may affect girls' interests in science and technology as often these things are viewed by girls as 'childish boys' interests'. From her interviews she commented "The girls also regarded their own behaviour as grown up in contrast to the boys' childishness. Femininity was constructed as associated with maturity" (Pg 39).

Therefore, when contemplating a career choice, girls' own self image and their perception of the image of science contribute to the decision making process. Baker and Leary (1995) concluded from their interviews that girls rejected physical sciences because they did not see physical scientists as caring or helpful. Essentially, girls are confronted with the contrast between their own self image and the image of science perpetuated through their education, where modern science is seen synonymously with a masculine way of viewing the world. Modern science places female ways of knowing in opposition to itself.

Weinreich-Haste (1986) argues that the dualism of gender is mapped onto man versus nature, reason versus passion, control versus uncontrol, logic versus intuition and the atomisitic approach versus the holistic approach. Fox-Keller (1986) sees "deep interpenetration between our cultural construction of gender, and our naming of science" (Pg 173). She argues that science is seen as rational, objective and transcendent and that the male is seen as having these qualities. The female however, is placed in opposition to this and is viewed as irrational, subjective and imminent. It is by these processes that we arrive at a modern science which Harding (1986) describes "is very widely seen, both now and in its origins as being more closely tied to characteristics disproportionately distributed to men" (Pg 134). Eastlea (1986) illuminates important ingredients in the masculine image of modern science, with special reference to physics. The predominance of aggressive, competitive behaviour and the remoteness of concern with living beings are pervasive. Physicists with masculine qualities are judged better to handle the 'scientific method' whereas women are more adept at intuition. Nature is personified as female and it is the job of male-science to conquer her. There is also an image of physics being inextricably linked to the military and accompanying arms race. It is not surprising then, that girls and women, whose socialisation determines that they examine the whole problem and not parts thereof, have concerns for social implications and see things in terms of relationships, find modern science alienating and undesirable.

2.3.3 Teacher attitude to and ability in science

Primary school teachers of science have had a tendency to feel apprehensive and negative about the teaching of science (Goodrum et al., 1992). Lack of content knowledge in the science field often contributes to apprehension in teaching science. Lee (1995) in examining the practices of two middle science school classes concluded that the teacher resorted to heavy dependence on 'seat work' from the textbook, avoiding whole class and group activities, so as not to reveal lack of content knowledge. Recently Harlen and Holroyd (1997) found a similar result when interviewing 36 primary teachers in Scotland about their understanding of science concepts. Of the 36 there were 10 teachers who had both a high level of understanding and high confidence in teaching science. The other 12 were both low in understanding and low in confidence. The researchers concluded that the teachers with low content knowledge and low confidence would be likely to employ methods to avoid or cut down their science teaching time.

Tobin et al. (1990) have coined a term to encapsulate the cognitive factors which they argue have direct influence on how the teacher structures the learning environment. They refer to 'teacher mind-frames' including beliefs of teachers, their conceptualisation of the teaching role, the knowledge of science content to be taught and the teacher's knowledge of how to teach the science content. They argue that both knowledge of science content and how to teach it are equally important. Even exemplary teachers of science can experience difficulty when teaching outside of their area of expertise. Happs (1987) found that low levels of content knowledge, even in an exemplary science teacher, can result in the naive views of students not being challenged or incorrect scientific concepts being reinforced.

Koballa and Krawley (1985) argue that a teacher's attitude towards science influences their students' attitudes and is reflected "in the time the teacher spends teaching science and the manner in which it is taught" (Pg 229).

2.3.4 Teacher practice in science

There are strong links in the literature between teacher attitude to and ability in science and its influence on classroom practice in science. Biddulph and Carr (1994) and Fraser et al. (1990) indicate that teachers' views about science and children's learning impact on science teaching practice. Stofflett and Stoddard (1994) posit that teachers reflect on how they have learnt science and emulate those methods arguing "it should come as no surprise that teachers who learned science through didactic methods teach science didactically" (Pg 45). Cronin-Jones (1991) argues that implementation of new curriculum is hampered when existing belief structures are incongruent with the underlying philosophy of the intended curriculum.

It has been discussed how lack of science content knowledge in science can result in a predominately 'seat work' approach to science teaching. The opposite of a 'seat work' approach to science teaching is described by Roth and Roychoudhury (1993) who examined the development of integrated process skills in the context of open enquiry laboratory sessions. The students planned, designed and implemented investigations of their own choosing. Having participated in the programme the students were able to isolate variables more adeptly as they became more familiar with the context, generate fruitful hypotheses and became actively engaged. However, Roth and Roychoudhury (1993) warn that "allowing students to choose problems of their own interest entails an underlying intellectual expectation from the teacher. Students may come up with problems that require an in depth knowledge of the subject matter on the part of the teachers as facilitator" (Pg 148). Osborne and Freyberg (1985) trialled prepared materials to support the Learning in Science Project and noted a similar relationship between teacher lack of confidence and competence in relation to exploratory work stating "teachers may also lack confidence and competence in certain topic areas. For biology and chemistry graduates, electricity topics can often be a good example of this. In such situations the more open-ended work of the exploratory and application phases can build up to a threatening situation and once more distortion of the proposed teaching programme can result" (Pg 123).

Participation in open-ended investigations such as these has been found to have a strong predictive value on science persistence in later years (Gallagher, 1994). Harlen (1989) also argues that science education where ownership of ideas is promoted is more likely to provide equal opportunities for both sexes than a traditional 'transmission' approach. When examining the problem of teacher knowledge and teacher confidence in Australia, Jean and Farnsworth (1992) reported that "a substantial proportion of teachers agree that some of the problems could be alleviated by having a set course together with simple prepared kits containing sample learning experiences. Any such materials must make provision for individual teachers to capitalise on critical teaching incidents as they arise and must or undermine the professional pride that teachers have in their work." (Pg 214).

In their analysis of textbooks and activity guides as a means open-inquiry teaching, Pizzini et al. (1991) conclude that ultimately the responsibility rests with the science teacher as the 'pre-prepared' materials they reviewed were not designed to facilitate open-inquiry teaching.

It is possible that teachers want to use open enquiry investigations in science teaching, but find themselves stifled by pragmatic issues such as lack of time and resources.

Schoeneberger and Russell (1983) examined the place of science in the elementary curriculum from the teacher's perspective and concluded that it was regarded as a 'frill'. One of the perceived barriers to teaching science was the lack of materials readily at hand. This caused irritation to the teachers. One could conjecture that this could influence the teacher's attitude towards teaching science, and therefore the programme being offered to the children and consequently their attitudes to science. Also the lack of a staff member designated as a science support person was perceived as a difficulty. It is interesting to note, however, that when classroom teachers were surveyed regarding what they wished from a science coordinator (Moore, 1992) they displayed some reluctance to accept classroom based support from coordinators and to share responsibilities with them.

Even in studies of exemplary science teaching it has been shown that the management of resources and ideas can be a challenge to the teachers. In his study of exemplary upper primary science Goodrum (1987) found a "difficulty involved the support structures available to assist teachers in implementing worthwhile science education. This support revolves around equipment and ideas" (Pg 91). New Zealand teachers of form two students also find frustration with lack of equipment for science teaching. New Zealand results from the Third International Maths and Science Study (Garden, 1996) show that from factors that limit how teachers teach their science class 'quite a lot or more', 44 per cent cited lack of student instructional equipment, 43 percent lack of equipment for teacher demonstrations and 40 percent inadequate physical facilities.

The literature pertaining to beginning teachers refers to the conflict between the 'optimal model' of teaching science as presented at teachers' college, and what is actually possible within the culture of the school in which they are employed. Fernandez (1994) discusses three such teachers, all of whom had modified the teaching approaches learnt at pre-service level, by the end of their first year teaching, as a result of lack of time, resources, lack of collegial support and in the face of the dominant culture of learning in the school. Bryd and Doherty (1993) in examining constraints to teacher change in science education in a high school also identified lack of lesson preparation time as a constraining factor.

2.3.5 Student achievement and attitude

Another factor which impacts on attitude to science is achievement, although there is debate regarding the direction of this effect. In 1983 Steinkamp and Maehr conducted an analysis of 66 articles and reports and drew correlations between affect, ability and achievement in science. They concluded that affect and achievement reinforce each other but cognitive ability had a stronger causal link to achievement in science than positive attitude. They argue that as students actualise their ability in science and achieve, they are more positively disposed towards the subject, " moreover, one can interpret the results as suggesting that it is primarily the acquisition of proficiency that leads to positive attitudes" (Pg 389).

Rennie and Punch (1991) argue similarly, that science related affect or attitude is strongly related to previous science achievement, so that doing well in science will feed into positive attitudes towards the subject.

However, Simpson and Oliver (1990) argue that attitude to science and achievement in science run parallel to each other, feeding into 'science self concept' which determines uptake and achievement in science in later schooling.

2.3.6 Classroom and school environment

A broader field of research in science education which encompasses teacher effect as well as effect of classroom activities is that of research into classroom environment. Hofstein et al. (1982) argue that "the atmosphere and environment in which students encounter science affect attitudes towards science and achievement in science" (Pg 349). Myers and Fouts (1992) found that positive attitudes towards science were found in classrooms which had "high levels of involvement, high student to student affiliation, high teacher support, high order and organisation, high teacher use of innovative teaching strategies, and low level of teacher control" (Pg 936). This has interesting implications for the role of the teacher, to give high support but in a non-controlling way. Baker et al. (1992) found in studying attitude to science, that in general students prefer group activities and very open-ended lessons. He argues that these factors contributed to 'classroom structure' and that classroom structure was a powerful correlate of attitude towards science and deserves further examination.

Talton and Simpson (1987) investigated relationships of attitude toward classroom environment with attitude toward science. They examined six areas contributing to classroom environment: emotional climate of the science classroom, science curriculum, physical environment of the science classroom, science teacher, other students in the science classroom and friends attitudes toward science. They concluded that student attitudes towards classroom environment predicted between 56% to 61% of the variance in attitudes towards science. Fraser (1987) has a keen research interest in the environment of science classrooms. When studying exemplary science and maths teachers Fraser examined the psychosocial environment of their classrooms. The exemplary science teachers' classrooms were perceived as having markedly more satisfaction, less friction, less competitiveness, less difficulty and more cohesiveness than their comparison group 'regular' classroom.

Looking more broadly than the classroom, to a whole school perspective, there is some evidence that when comparing schools, the size and type of the school and the school science support available may influence attitudes to science.

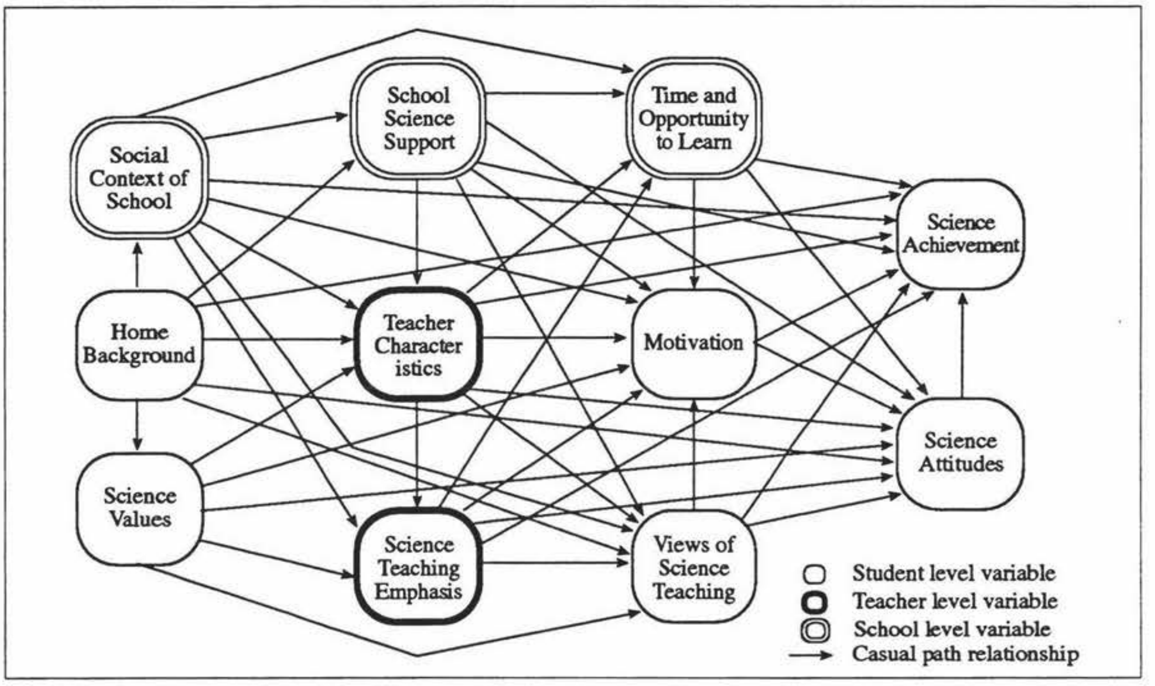
In New Zealand Crooks and Flockton (1995) reported interesting findings regarding the relationship of student attitude to science to school size and type. As the size of the school increased, student enthusiasm about science compared to other subjects decreased. Students from the largest schools were least likely to say that they were proud of their best work in science at school. Fitting with this pattern, students attending intermediate schools (as compared with full primaries) were less enthusiastic about science when comparing it to other subjects and were less likely to say they were proud of their best work in science at school. In contrast, students from rural areas gave the most positive ratings to a question which asked how often their class did really good things in science. However, these attitudes could be affected by the fact that intermediate schools are found in cities and often in low socio-economic areas. In addition the short length of time students are in intermediate school could influence their attitude.

The support available for science teaching within the school may also impact on teacher and student attitude to science. In a secondary context, Burns (1988) in evaluating senior chemistry in New Zealand found that the amount of financial assistance received to support science teaching appeared to depend on the "liveliness of the science staff, particularly the head of science, their appreciation of the needs of science teaching and their enthusiasm in pursuing the fulfilment of those needs" (Pg 171). In addition schools with developed support networks were better off for up to date text books supplies, than were schools without such support. These conclusions have implications pointing to the importance of broader mechanisms supporting science teaching, as Harlen (1992) suggests.

The Second International Study of Science, reported in Keeves (1992), identifies school level variables which have a causal path relationship with science attitudes. The social context of school is posited as influencing the teacher level variables of teacher characteristics and science teaching emphasis as well as the school level variable of school science support and time and opportunity to learn science. School science support is also argued to influence science attitudes directly as well as indirectly through student motivation, see Figure 2.2 over.

Figure 2.2

Causal model for between school analyses.



Lorbach and Tobin (1995) argue that for classroom learning environments to have the greatest chance of improving, the school learning environment also needs to be addressed. This is supported by Wildy and Wallace (1995) who, after examining the practices of an experienced physics teacher argue "Teachers and students do not construct knowledge in a vacuum. The way they teach and learn as well as their choices about what to teach and learn are integrally connected to the social and cultural contexts of schooling. School science sits with school culture" (Pg 154). Therefore, the context of science in the school and how the school supports it has been seen as influencing attitudes to science.

2.4 School Culture

In this section the concept of school culture and classifying cultures will be discussed.

A useful definition of 'culture' in the context in which it will be used in this study is provided by Clark et al. (1981). "The 'culture' of a group or class is the peculiar and distinctive 'way of life' of the group or class, the meanings, values and ideas embodied in institutions, in social relations, in systems of beliefs, in mores and customs, the uses of objects and material life. Culture is the distinctive shapes in which the material and social organisation of life expresses itself" (Pg 52). Marsh and Beardsmore (1985) argue that one way to describe culture is to identify four sets of factors: shared things, such as symbols, manuals or logos, shared sayings or slogans, shared activities or actions and shared feelings or climate. They argue that these factors give clues to the underlying shared values and beliefs held by people who work in the same place. Schien (1985) and Beare, Caldwell and Millikan's (1989) models of culture incorporate the elements articulated by Marsh and Beardsmore (1985) but embody them in a more encompassing and coherent framework.

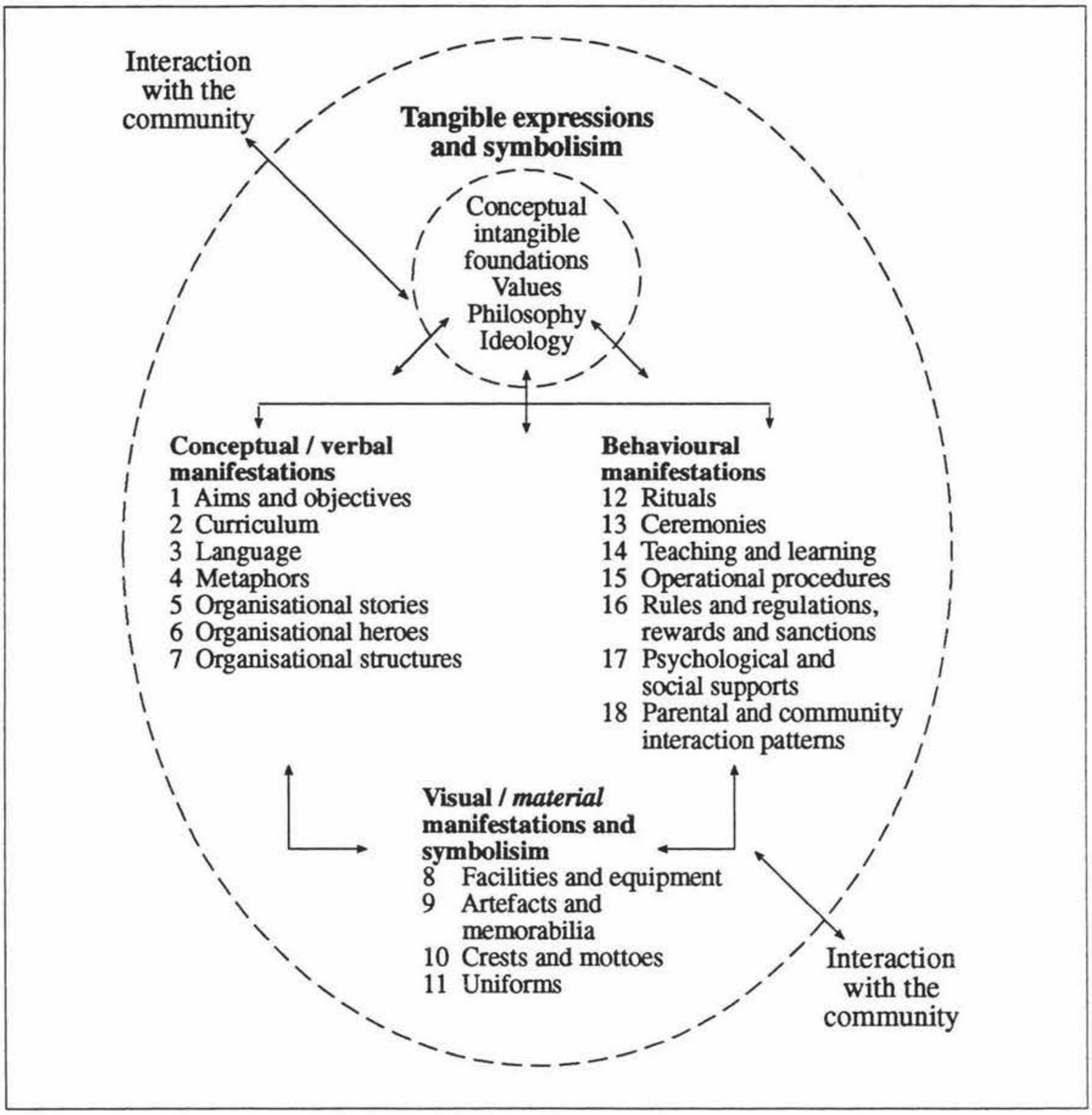
Schein's (1985) model of culture comprises three levels. In level one, the highest level, are the most obvious manifestations of culture which are visible and audible. This includes art, technology, human behaviour and speech. The next level is level two which comprises the values of the organisation, underpinning the obvious manifestations. These values can at times be read in documents such as a 'mission statement'. Owens and Steinhoff (1989) argue that these values also reflect the underpinning third level of basic assumptions. The third level is the most basic level, and it is argued that this is where the basis of culture is found. Many of these assumptions are taken for granted and are out of consciousness.

A more structured and detailed model of culture has been advanced by Beare, Caldwell and Millikan (1989) for use in educational settings and is presented in figure 2.3 over. Their model is represented in a core of values. In this core are the 'conceptual intangible foundations' of culture. These include values, philosophy and ideology. Tangible expressions of these foundations, it is argued, are evidenced in conceptual, verbal, behavioural and visual manifestations of the organisational culture. Conceptual and verbal manifestations include details such as aims and objectives, curriculum, language, metaphors and organisational stories, heroes and structures. Behavioural manifestations of the culture include details of rituals, ceremonies, teaching and learning, operational procedures, rules, psychological supports and community and parental interaction patterns. Visual manifestations of culture can be seen in facilities and equipment, artifacts, crests and mottos and uniforms. Tangible expressions of culture are also visible to and interact with the community.

There are similarities between Schein's (1985) concept of culture and Beare et als (1989) in that they both focus on the observable to access the underpinning values and assumptions which form the foundation of culture. Schein (1985) writes and researches with a focus on the business community, whilst the work of Beare et al. (1989) is focused with educational contexts in mind. In terms of a model upon which to structure research Beare et al. (1989) provides a more detailed framework for an educational setting and will be employed in this study. Schein (1995) uses the term 'organisational culture', while Beare et al. (1989) employ the term 'school culture'. As this study is utilising Beare et al's model, and it is set in a school, this study will use the term 'school culture'.

Figure 2.3

Model of culture - Beare and Millikan (1989).



However, not all writers agree with such conceptualisations of culture. Bates (1987) argues that writers of culture theory have made an error in treating culture as synonymous with managerial culture. He posits "They are not, for example, incorporating consideration of the interests of the workers into their analysis, except for the assumption that what is good for the corporation is good for the workers too. This assumption is, to say the least, questionable" (Pg 82). He argues that interest in culture has come about so managers can manipulate it for their own ends and educational researchers such as Beare et al. are adopting the same manipulative tradition in education. At the foundation of Bates' (1987) argument is that the conception of culture and the overt pursuit of 'excellence' is in fact 'high culture'. He advocates a 'cultural studies' perspective where "the culture of a society cannot be understood unless the nature and organisation of the relationships and struggles between dominant and subordinate cultures are taken into account" (Pg 849). However, if the alternative 'high culture' definition of culture is adopted he argues "then the administration can be judged as successful or unsuccessful according to how well it can reproduce that culture among those who have inherited it and produce that culture among those who have not or at least persuade those who lack such an inheritance that they are devoid of talent or worth" (Pg 91).

While Beare et als (1989) model will be used as a framework for this study, the arguments posited by Bates (1987) will be revisited and discussed with regards to the findings of this study, in Chapter eight.

2.4.1 Classifying cultures

Handy (1985) has identified four classic organisational cultures: task, role, power and person. The 'task culture' is focused on channelling all resources and energy into completing a goal or task. The organisation and those within it adapt and work together to meet the goal. The 'role culture' is based on strong descriptions of people's roles within an organisation and there is no deviation from these. A 'power culture' is based on a central powerful figure, from whom vision and energy comes. Problems can arise when the central figure requires replacement. A 'person culture' exists to support its members. People belonging to a person culture work together for the sense of belonging to a group, not with a focus on profit. However, Schein (1986) disagrees with the concept of classifying organisational culture in this way. He argues that researchers have not studied enough organisations to posit that 'culture' fits into types and that each organisation has its own peculiar type of culture. He argued that it is more fruitful to describe and represent cultures accurately than look for a 'type' to classify it with.

Owens (1987) argues that organisations and schools contain a mix of cultures where subunits of people will hold their own shared values, beliefs and assumptions which may be different from other subunits of people within the school and this a view which the writer of this thesis supports.

Researchers have also speculated about factors which contribute to strong cultures. Strong cultures have been defined as when the members of a culture have strongly held shared assumptions (Schein, 1992). Mitchell and Willowers's (1992) theory of reinforcing elements contends that within the school culture there are both adult and children's sub-cultures. Differences or opposition between these sub-cultures can mean an ineffective organisation. They argue that "for the students to share significant elements of culture with the organisation's adults, the student groups will have to internalise certain adult expectations regarding school work. This is more likely to occur when their relationships with their teachers are good, when they face similar expectations from other sources, and when there are elements in the student sub-culture which reinforce those expectations" (Pg 15).

Schein (1992) contends that there are ways in which leaders embed and transmit culture. His posited primary and secondary embedding mechanisms relate to the elements which Beare et al. (1989) include in their model of organisational culture. Each will be outlined.

Schein (1992) suggests that what leaders pay attention to and control on a regular basis will reinforce the culture. How leaders react in a crisis, how they allocate scarce resources, their role modelling and coaching, how they allocate rewards and how leaders recruit and promote staff are all primary embedding mechanisms. The secondary mechanisms only work if consistent with the primary ones above. Schein's secondary embedding mechanisms which also aid in reinforcing culture are: the organisational structure, the systems, the rituals, the building design, stories about people and events and formal statements of organisational philosophy.

2.5 Research Problem and Questions

Harlen (1992) argues that research is needed at the levels of school and class planning of primary level science teaching and learning as there is a paucity of research at this level of schooling, particularly in the implementation of science. More specifically related to the investigation of attitude, Haladyn and Shaughnessy (1982) argued that most of the studies of attitudes to science have limited their focus to differences between boys and girls, longitudinal trends over grade levels for restricted periods of time or the effects of various programmes or methods of instruction on science attitude. They called for a broadening of scope in the research on attitudes to science.

While many studies have addressed factors which affect student and teacher attitude to science and therefore later uptake of optional science study, none tell the full story of how a science curriculum is interpreted, planned for and implemented within a school, how the school chooses to value science and the teachers and students attitudes to science. While some studies have investigated relationships between individual factors and attitude, relationships between factors have been ignored. No studies have described the 'multi-levels', or 'nested systems' explained by Charron (1991a), in which those who learn and teach primary science operate.

The New Zealand-wide studies of attitude to science undertaken by Crooks and Flockton (1995) and Garden (1996) have provided a recent overview of attitudes. However, while broad surveys such as these provide a global view, they do not illuminate reasons for attitudes or examine site-specific issues such as teacher support which affects curriculum delivery and student attitude (Keeves, 1992).

No studies have investigated possible relationships between attitudes to science and the culture of science in the school. Therefore this study aims to investigate the problem of whether and what type of relationships exist between the culture of science in the school and attitudes to science. The attitudes of the students and teachers in the school and the culture of science in the school will be examined.

Gallagher (1994) and Simpson and Oliver (1990) have identified the middle school or intermediate school age as a critical point where positive attitude to science can be improved and this can enhance future uptake of science. Kelly (1986) whose research also focused on this age group, argued that some schools are successful in promoting positive attitude to science and that detailed case-study is necessary to identify the central factors which produce these effects in order to reproduce them in other schools. Therefore the problem to be investigated is located in an intermediate school which has been successful in science.

The specific research questions which frame this study are:

Question One:

What are the attitudes of intermediate school students' towards science in the school examined?

a. What is the nature of the students attitudes to science?
b. How do students' attitudes to science interact with school level (form one and two) and gender?

Question Two:

What is the culture of science in the school examined?

a. What are the underpinning values of school science culture?
b. What is the nature of teachers' attitudes to science and its teaching?
c. How is science represented in the school curriculum documents?
d. What form does school science take?
e. What are the resources and symbolic elements of the school science culture?

Question Three:

How does the culture of science in the school relate to the students' and teachers' attitudes to science?

Chapter Three
Methodology

This chapter will outline the data gathering and analysis procedures employed in this study. Initially it will describe the overall method of the study and then the way data were collected and analysed from the context, teachers and students.

3.1 Overall Method

The overall methodology selected for this research was a single-site case study. It focused on an Intermediate school in a middle class suburb of Auckland's North Shore.

Case study has been described as "an umbrella term for a family of research methods having in common the decision to focus on enquiry and an instance" (Adelman et al. 1976, Pg 1) and as "a study of a 'bounded system' with a conception of unity or totality" (Smith cited in Stake, 1980).

Yin (1981) provides a technical definition of case study:
"A case study is an empirical enquiry that:
a Investigates a contemporary phenomenon with its real life context when
b the boundaries between phenomenon and context are not clearly evident and in which
c multiple sources of evidence are used" (Pg 23).

The case study approach will allow answers to be obtained for the questions this study is asking, as science within Bayside school is a phenomenon in its real context, the boundaries between science delivery and the school itself are indistinct and multiple sources of data will be used.

The definition of what case study is can also be informed by what it is not. Adelman et al. (1976) emphasise that case studies are not simply observational studies nor purely pre-experimental. Neither is case study a name for a standard methodological package. They argue that case study methodology is eclectic, researchers being able to use a potential range of structured and unstructured interviews, participant and non-participant observations, field note-taking, document collection, audio visual recording and negotiation of products. Adelman et al. posit that case studies can be set up in two ways. The first is when the instance or bounded system studied is drawn from a class. This instance could be chosen because of its representativeness of the class. The second way to set up a case study is to choose a bounded system in which issues are discovered and as full an understanding as is possible is developed of this system. This research is of the first type. Although Bayside school is not representative of all other schools with regard to science, it is representative of a subset of schools who have success in science. It has a disproportionate number of students who win science fair awards, when compared to other schools and an entrenched system of science delivery. The 'bounded system' selected is the system of science delivery at Bayside School. The boundaries to the case are science delivery although this does reach into the community and homes as this is where science projects are completed. Other subjects in the school will not be examined and the school itself will only be examined as far as it relates to the system of science delivery.

An interpretivist approach is suitable for this study. Hughes (1990) argues that interpretivism grew as a reaction against the positivist use of natural science methods to make sense of human actions. Another method was sought which "had to recognise the actions events and artifacts from within human life, not as the observation of external reality" (Pg 90). All 'constructions' be they art, society, thoughts or any human product could therefore be understood by the "apprehension of their inner meaning; the meaning that lead to their production" (Pg 90). An interpretivist approach is therefore suitable for this study as the inner meaning of school science culture is sought. Case study fits well in an interpretivist approach to research and the tools of case study are an asset to the researcher working from an interpretative perspective. Meanings can be surfaced by the triangulated use of interview, observation, data collection and survey, thus also taking precautions for reliability (Poskitt, 1989). Smith (1989) articulates an additional strength in "the inseparability of facts and values (which) is the essence of interpretive enquiry" (Pg 111).

An interpretive approach is appropriate for this study as Charron (1991a) and Harlen (1992) have both argued the necessity for a broader frame of reference for science education research. Charron posits that a social-contexts frame of reference is useful as it grounds socially constructed meaning in a particular time and place, it describes contexts in detail and uses participant perspectives. These features result in a description of a multi-level or nested system, describing the context and the participants within it. Charron argues that this type of research is necessary in science education as it provides a more holistic picture of the variables that effect science outcomes.

In case study the researcher is not standing outside the scene but is within the frame. However, there have been concerns raised about single triangulated outcomes. Mathison (1988) explains when the triangulation strategy is used, it is assumed the result will be convergence on a single perspective of the topic under study. More illuminating, she argues is the use of inconsistent and contradictory data as well as convergent data. Inconsistent and contradictory data can be made sense of by interpreting it with regard to "a holistic understanding of the project itself, its history, the intentions of the developers, the ongoing relationships within the project and so on ..." (Pg 16).

This study focused on one intermediate school which had success in science. The intermediate school age has been identified as "one of the nodal points during which students' interest in science can be enhanced, increasing the size of the initial talent pool" (Gallagher, 1994, Pg 772). Kelly (1986) concludes that schools can and do have an effect in promotion of positive attitude to science and that detailed case-study work is necessary to identify the central factors which produce these effects in order to reproduce them in other schools.

Burgess (1982) argues that selecting the research site is part of the sampling process and cites Spradley's (1980) identification of five criteria in the selection of research site. "First, simplicity; that is a research site that allows researchers to move from studying simple situations to those which are more complex. Secondly, accessibility; that is the degree of access and entry that is given to the researcher. Thirdly, unobtrusiveness; that is situations that allow the researcher to take an unobtrusive role. Fourthly, permissibleness; that is situations that allow the researcher free or limited or restricted entry. Fifthly, participation; that is the possibility for researchers to participate in a series of ongoing activities" (Pg 61).

The school selected, from the subset of successful science schools, fulfilled most of the above five criteria. It afforded generally good access as the researcher was employed there under a supportive Principal. Where it afforded only limited access, this was a result of the researcher's role as a teacher in the school and therefore the researcher provided a threat to some when observation of classroom teaching was requested.

In order to gain access to the school the parameters of the study were discussed with the Principal and a letter was forwarded to the Board of Trustees. The Principal replied on their behalf giving permission and stating that they would be interested in the conclusions reached. The staff were also consulted, presented with an overview of the proposed study and asked for collaboration.

The school selected was successful in science as the students won science awards and the school appeared to emphasise science in the systematic way it organised the subject. In 1994 the school was awarded a certificate by the Royal Society for their efforts in promoting links between the school and the community in science endeavours. It is for these reasons that this school, given the name 'Bayside School' for the purposes of this research, appeared an interesting site for a study examining school science culture and attitudes to science.

The study spanned one full school year, during 1995, and the data gathered over that period consisted of documents, surveys, a self-reflection questionnaire, interviews together with observation of school science events. This range of information collection was in keeping with a case study approach (Adelman et al, 1976) and allowed for a range of perspectives to be triangulated (Poskitt, 1989). Document analysis and informal observation provided answers to the questions 'how is science represented in the school curriculum' and 'what is the form of school science?', surveys completed by the students at Bayside and student focus group interviews provided insight into the question 'what are the attitudes of intermediate school students towards science in the school examined?'. Interviews with teachers and a self-reflection questionnaire, gave answers to the question 'what is the nature of teachers' attitudes to science?' All classroom teaching staff, management staff and students of the school were involved in providing data.

The researcher's position as a teacher in the school, while undertaking research, was one that presented challenges in two main forms: challenges brought about as the researcher was an 'insider' and more pragmatic concerns regarding the researcher also teaching full time.

Potentially, the researcher's values and allegiances as an 'insider' in the school, could impact upon the design, collection of and interpretation of data. In addition every effort was made to avoid procedures which could be interpreted by other staff members as evaluative. To allow for changes in data collection technique when those in the field felt threatened, the methodology was generative, (Alton Lee, 1992) and was able to be changed. The possibility of threat perhaps heightened as the researcher was an 'insider'. A generative methodology also allowed for flexibility if new questions arose in the field which deserved investigation.

Teaching full time in the research field restricted the type of data which could be collected, in particular, it restricted observation undertaken in classrooms. Also it meant careful negotiation of interview time with other teachers, survey time with their classes and access to pupils for focus groups interviewing was necessary. However, there are many been positive aspects of a teacher/researcher as insider. Lytle and Cochran-Smith (1992) argue for teacher research as a way of knowing, saying that "teacher researchers are uniquely positioned to provide a truly emic perspective that makes visible the ways students and teachers together construct knowledge. When teachers do research, they draw on interpretive frameworks built from their own histories and intellectual interests" (Pg 448).

3.2 Ethics

Burgess (1989) argues that the relationship between the researcher and the researched should involve "a respect for the rights of the individual whose privacy is not invaded and who is not harmed, deceived, betrayed or exploited" (Pg 61). To avoid invasion of privacy for the school in which this study is set and to preserve the identities of those who work there the school was given the pseudonym 'Bayside School'.

To avoid harm and exploitation, it was important that participants' informed consent was obtained and that anonymity as well as confidentiality was ensured.

Informed consent is a central ethical issue in educational research in which people choose whether or not to participate in a study. Cohen and Manion (1991) argue that there are four parts to informed consent; competence, voluntarism, full information and comprehension. The person invited to give consent must be 'competent' in that they will make correct decisions if given the correct information. Voluntarism refers to the participant choosing to take part in the study, or not take part voluntarily. The potential participants must be given full information about the nature of the study on which to make their decision and they must also comprehend the nature of the study before choosing to give or not give their consent. The researcher was careful to ensure that all participants in this research were fully informed and gave their written consent. For both staff and student interviews, (See Appendices Two and Three respectively) information sheets and consent forms were distributed, signed by participants and returned before proceeding. In the case of the student survey, students were invited to complete a questionnaire and were informed of the reasons for its administration verbally by the researcher and on the front sheet of the instrument (see Appendix Three). The staff were also invited to complete their self-reflection questionnaire of science teaching practice and were fully informed of the reasons for the administration of the questionnaire on the front sheet (see Appendix Two). Teachers and students were also given typed copies of the transcripts of their interviews and asked to return them to the researcher with any corrections they thought necessary.

Also to avoid harm and exploitation, care was taken not to take up too much of the students' class time, nor to impose too much on the teachers' preparation time. Anonymity is another important facet of ethics when undertaking educational research. Cohen and Manion (1991) argue that "information provided by participants should in no way reveal their identity" (Pg 366). They posit that the principal way of ensuring anonymity is by not using the participants names or any other identifying features. The student questionnaires in this study were completed anonymously as were the staff self-reflections on science teaching practice. All participants were ensured that either codes or pseudonyms would be used in subsequent writing up of the results of this research, therefore they would not be identifiable and potential harm avoided. Both students and teachers were ensured of confidentiality on the information sheets and consent forms for the survey instruments and interviews.

3.3 Data Collection From The Context

Document analysis and informal observations were undertaken to address research question two "what is the culture of science at Bayside school?" and the related sub-questions:

a. 'what are the underpinning values of school science culture',

c. 'how is science represented in the school curriculum',

d. 'what is the form school science takes' and

e. 'what are the resources and symbolic elements of school science culture?'

3.3.1 Content analysis of documents

The New Zealand science curriculum requirements and the way in which they are interpreted in the school scheme, newsletters, teaching material in the science room, Science Fair records and other science-related materials were read and analysed for common themes (Babbie, 1992). These materials were examined for clues to the underpinning values of school science culture.

3.3.2 Informal observation

Having been employed on the site of this study for three years and having played an active role in the yearly life cycle of science in the school, the researcher was familiar with the school's system of organising science. In addition, during the period of this study, the researcher took notes at significant events such as the Science Fair parents' evening and pertinent staff meetings.

(i) Data handling

After data was collected from the context, it was examined for common themes and reported in Chapter four. This data is also used in triangulation with interview and questionnaire data in Chapter seven where the values underpinning science delivery are described.

3.4 Data Collection From Teachers and Management

All classroom teachers, technicraft teachers and management staff were interviewed about their attitudes to science. In addition, all classroom teaching staff were invited to complete a self evaluation questionnaire of their science teaching practice.

3.4.1 Teacher interviews

In this section, the construction of the interview schedule, the participants and the administration of the schedule are described.

(i) Instrument construction

A decision was made to use interviews to obtain information from the teachers as interviews allow the researcher to clarify unclear responses and to probe for additional information (Sax, 1979). The interview would be classified as an informal respondent structured interview (Cohen and Manion, 1991), as the questions were set out in the interview schedule and were the same for each teacher interviewed. The interview schedule for the teachers and for management can be found in Appendix Two. It addressed teachers' school background in science, science education training at Teachers' College, length of service in teaching at Bayside school, their attitudes towards science badges and science fair and their attitudes to science teaching generally. This information provides answers to the research question: "what is the nature of teachers attitudes to science and its teaching?"

Research has shown the relatively low level of academic science undertaken by people who later train as primary school teachers, (Goodrum et al., 1992), therefore the opening questions in the interview schedule refer to the teachers' background education in science.

The questions regarding school and Teachers' College science education courses undertaken were included to gather information which could indicate degree of interest and commitment to science as a teaching subject. The 'closed' questions pertaining to length of service generally and at Bayside school provide some background to the population which may be useful in interpreting other information gathered.

The major open question was "how would you describe your attitudes to teaching science?". The idea of plotting the attitudes to teaching science on a continuum was suggested by the first teacher to be interviewed and this was subsequently utilised in the other interviews in addition to the open question, (and therefore is an example of the use of generative methodology). This also meant that attitudes could more easily be compared. The researcher also probed for elaboration and clarification of teachers' responses (Sax, 1979).

Participants were invited to comment on any values they perceived underpinning science delivery in the school. Although Schein (1992) argues that one should not ask 'key informants' for their impressions of the underpinning values of an organisation as " not only are such questions likely to produce what the informant thinks is socially desirable and acceptable, but even if she or he is not motivated by social desirability, the informant is unlikely to be able to focus on these categories" (Pg 177). This may underestimate the reflexivity and perception of many teachers. Therefore many potential insights could be lost by not asking values questions. Therefore all classroom teaching staff and management were invited to comment on values. Those who felt unable to comment as a result of a short term of service at Bayside school said so. Others who did offer comment and had been there a short time, often qualified their insights with a reminder of their brevity of service. In only one case, a teacher offered comments followed by "is that what you are after? ". These comments were discarded.

Instead of directly asking informants of their perceptions of underlying values, Schein (1992) suggests "the outsider should ask questions that produce a natural story, that access the informant's thoughts and memories in a way that they are naturally organised, that is chronologically" (Pg 177). This approach was taken, with someone perceived to be a 'key' informant, the teacher with responsibility for science. As this teacher is a long-serving teacher at Bayside school, the instigator of the systems presently in place and the person in charge of science, it was decided to take this more lengthy approach. The questions of the standard interview schedule were incorporated in the dialogue.

Teachers were also invited to comment on the science badge and science fair schemes as these form a significant part Bayside's school science programme. The final question provided an opportunity for any other comment.

As the technicraft teachers have never taught the science curriculum, they were not asked the same questions as the classroom teachers. The only question they were asked was what links they perceived between their subject and the teaching of science.

The classroom teachers', management staff's and technicraft teachers' responses to these questions are summarised in the Chapter five - 'Teachers' Perspectives on Science Teaching'.

(ii) Population

The target group was the population because every member of the 16 classroom teaching, three management and four technicraft staff consented to be interviewed. Further break-downs of characteristics of teachers are reported in Chapter five.

(iii) Administration

With the participants' permission, these interviews were tape recorded and transcribed. It was decided to begin interviewing as soon as possible in the academic year. As there had been a number of staff changes, the teachers who had been at the school for more than a year were interviewed first because they had more familiarity with the school's way of organising science. Those who were having their first term at the school were left until last. As a result of before and after-school meetings, planning and other teacher commitments, access to staff for interviews presented a challenge. However, all staff made an effort to make themselves available. The interviews took between thirty and forty five minutes each. Most of them took place in the school's interview room, but some teachers suggested using their own classroom after school.

(iv) Data handling

After each interview was audio taped, it was transcribed. Twenty copies of each were made. Bogan and Biklen (1992) suggest taking long undisturbed periods of time to read over the data collected at this stage. They then suggest generating preliminary coding categories for each emergent theme in the data. After some refinement, when the coding categories have been decided on, all of the data is coded using these. They then suggest cutting up the data and putting it in folders denoting each theme. This is similar to Glaser and Strauss's (1967) concept of 'grounded theory' where they argued that theory should be grounded within research, be deduced from the data and not be influenced by outside theory. However, Altrichter and Posch (1989) have updated this idea and argue that one cannot dismiss preconceived theories from which researchers operate. Therefore this researcher acknowledges preconceived theories, obtained from reviewing the literature would could have informed the emergent themes found in the data.

The researcher used a modified version of Bogan and Biklen's (1992) suggested method of organising interview data. Having read the transcriptions several times, emergent themes made themselves apparent. These were informally noted on the researcher's white board. The transcripts were then put into manila folders under the main themes, with the relevant quotations within them highlighted. Within each emergent theme, 'the voices' of those who were sharing similar thoughts were grouped. To achieve this, the part of the teacher's interview, pertinent to that theme, was summarised on a piece of paper, so all views expressed on that theme could be viewed at once. Then those with similarities were grouped. Differences and contrasts were also sought out as being potentially informative (Fox-Keller, 1986). This was completed for each emergent theme. Then the results from the analysis of interviews were written up, with the descriptive data organised within the themes which emerged. When quotations from these interviews were used in the research, all teachers and management staff were given code numbers. The codes are denoted after each quotation as 't.XX'. The 't' representing 'teacher' although management staff were included on the same coding scale.

3.4.2 Management interviews

Management were asked an additional question to the rest of the teaching staff. The were asked in what way they supported the learning and teaching of science. This information provided a link between the scheme (what should be happening) and how the management perceive they support it happening. The interview schedule is given Appendix Two. All three management staff members answered this question in the same interviewing sessions as they answered the questions addressed to classroom teaching staff.

3.4.3 Teacher questionnaire

It had been intended that some observation of science lessons would take place, a sample of six teachers was to be selected to encompass a range in length of teaching experience and to be as representative as possible of teacher gender and ethnicity. This was intended to provide some links between intended teaching practices (the scheme), actual teaching practice and the children's attitudes to science. However, even those perceived to be the most 'open' teachers approached gave many reasons why such an observation would not be appropriate or suitable. The researcher suspects that, as a permanent and full-time staff member, as an 'insider' in the field, she provided a threat. Therefore an alternative to observation needed to be developed.

It was decided to take the approach of least teacher threat and devise an anonymous questionnaire where all classroom teachers could reflect on aspects of their science teaching practice.

(i) Instrument construction

The aim of the 'teacher practice self-evaluation of science teaching' questionnaire was that teachers would reflect honestly on their own practice and report this on the continuums for the items provided. Such an approach has as an associated problem, that teachers will 'do what is expected'. However, the questionnaire was anonymous and so they had no reason to try to present the appropriate view.

The instrument was devised from suggestions for 'enhancing achievement' taken from the Science in the New Zealand Curriculum (1993, Pg 10) and items from the Bayside science scheme section 'teaching approaches'.

The instrument was pilot tested on two intermediate school teachers from another North Shore school, who thought it a fair document to use for reflection on science teaching practice. A four point scale was selected to increase the range of responses and reduce the temptation to choose the mid-point of the scale.

(ii) Population

Fifteen out of the sixteen classroom teachers anonymously completed the questionnaire. Although repeated requests were made at staff meetings for the outstanding questionnaire, it was not forthcoming.

(iii) Administration

At a staff meeting the purpose of the questionnaires was explained, and teachers were invited to complete them anonymously in their own time. Teachers then returned the completed questionnaire to the researcher's pigeon hole in the staff room. A week after their circulation, general friendly reminders were made, at the morning staff meeting, that the researcher would appreciate the return of the questionnaires.

(iv) Data handling

When the questionnaires were collected, large grid sheets were constructed and tallys made of the responses to each question. Conclusions were formed from the patterns of data found.

3.5 Data Collection From Students

All students in the school were invited to complete a questionnaire including two attitude to science inventories and an open response section. In addition six focus-group interviews were convened to clarify emergent points of interest from the open response section of the questionnaire.

3.5.1 Attitude questionnaire

A questionnaire was used as they are effective in describing the attitudes of large groups of people (Anderson, 1990).

(i) Instrument construction

Two attitude inventories were used, namely Smail and Kelly's (1984) Science Curiosity Inventory and Image of Science Inventory. These were chosen because they both provided factors which claimed to measure different aspects of attitude to science. In addition they were able to distinguish gender, which was useful for one of the research questions.

Smail and Kelly (1984) designed the Science Curiosity Inventory to assess initial motivation, arguing that these initial interests should be built on and that "initial curiosity about a topic can motivate pupils to successful study" (Pg 90). The Image of Science Inventory was designed by Smail and Kelly (1984) to assess student's stereotypes of science and scientists. They argue that " It is possible that boys and girls have different images of science and that affects their willingness to study the subject" (Pg 94).

In addition to the inventories, an open response section was included on the final page of the questionnaire for students to note anything about science and/or science in the school that they wished to. The surveys were trialled with a class of form one students and a class of form two students at an intermediate school. Note was taken of the degree of language difficulty with regard to new immigrants and how much previous English language experience they had.

(ii) Population

The target group was the population because 518 students completed the questionnaires administered. These students were from a total population of 593 students. Therefore 87.4% of the population completed the questionnaires. 255 out of 283 or 90.1% of form one students and 263 out of 310 or 84.8% of form two students completed the questionnaires. All students present in the classes at the time the researcher was administering the questionnaires were invited to complete them. None declined. Those who did not complete them were absent on the day the questionnaire was administered to their class. Lack of time made catch up sessions not possible.

(iii) Administration

Administration of the attitude survey took place after the May holidays to allow all students some exposure to intermediate school science. The researcher asked the class teacher to indicate on a class list, the students who had English as their second language. The acronym ESOL will be used from this point to refer to English for Speakers of Other Languages. Those ESOL students were asked if they would like to complete the survey with a translator later in the term. Most of the ESOL students chose this option. All of the surveys were administered by the researcher during her non-teaching time, to ensure comparable conditions for all classes.

It was decided to administer the questionnaire to ESOL students with the help of peer translators. The ESOL teacher nominated three students who she knew as fluent in their own language and in English. The researcher sought agreement from these students, who were each native speakers of Korean, Taiwanese or Cantonese. They were given a copy of the survey an hour in advance of its administration and two students used a computerised translating device to check on their understanding of some science terminology. The classroom teachers had been given the names of the students (peer translators and questionnaire respondents) required in advance. When the ESOL students arrived in the classroom used to administer the questionnaire, they were split into their three language groups with one peer translator each. The student translator explained the purpose of the survey and read each item in turn, allowing time for recording of responses. In contrast to the rest of the school who completed their surveys in silence, the ESOL group appeared to discuss the items while completing the survey. It was difficult to tell whether the discussion was clarification of vocabulary or discussion of what various members of the group were giving as responses. However, the benefits of being able to include data from these students, was seen to outweigh the potential negative aspects of students completing the surveys in different conditions. Twenty four ESOL students completed the questionnaires in this manner.

(iv) Data handling

All of surveys completed were coded. The codes were entered into a data file and the data were cleaned. Using the Statistical Package for the Social Sciences (SPSSX, 1988) and a command file written to match, means and t-tests of population attitude and factor analyses were generated with respect to the entire population, gender groups, European and Asian ethnic groups and Form level. The data collected in the open response section were read closely for emergent themes and then sorted into categories. Where quotations from the open response section were used in the research, the student codes on each questionnaire were used, with the prefix 'S' for 'student'. Following the code number is the number one or two, denoting form one or two and the letter 'b' or 'g', denoting whether the student is a boy or girl. This helps to place the quotations in context. For example 'S19.2g', denotes student 19 was a form two girl. The results from the two surveys and the open response section are presented in the student results section, Chapter six.

3.5.2 Focus group interviews

In order to gain more detailed and descriptive information about the nature of students' attitudes to science and in particular science in Bayside school, six focus group interviews were facilitated with students. Anderson (1990) argues that focus groups go one step further than interviews to "provide a situation where the synergy of the groups adds to depth and insight" (Pg 241). The interviews were video recorded to preserve the responses of the interviewees for later transcription. As a number of students would be contributing to the discussion, transcription appeared easier if one could see who was speaking on the video monitor when transcribing, rather than trying to discern individual voices while listening to a tape recording. In addition, watching the students' body language gave valuable context to the interviews.

(i) Instrument construction

The focus group interview schedule was constructed following initial analysis of the open-response section of the survey data gathered. The focus group interview questions (see Appendix Three) aimed to clarify and provide more descriptive detail than the student information already gathered. The first block of questions focused on what the student liked doing and disliked doing in science, and why. Next, the terms ' fun, exciting, interesting and boring' commonly used in the open-response section of the student survey were investigated with regard to science activities, experiments and topics. As some students said in the open-response section of the survey they enjoyed science more when they understood it, the second block of focus group questions explored the student's conceptions of and feelings about understanding in science. The final group of questions explored the science undertaken in the student's own time, as the school scheme requires the completion of science fair and science badge projects in their own time.

The amount of structure and type of questions asked in a focus group interview is important. The questions asked related to the research questions and were not so structured as to suggest 'acceptable' responses (Stewart and Shamdasani, 1990). Questions were also worded as openly as possible, using 'what' and 'why'. Probing, elaboration and clarification was also used to maximise indepth response.

(ii) Sampling

When the researcher had collected the student questionnaires and thanked the class, she issued a general invitation to anyone who would like to participate in a group interview about what they think about science. A reminder was given of this at a school assembly also. Students then approached the researcher for an information sheet and permission slip. These were issued one month before the interview, giving full details of the procedures and asking for their and their parents' permission to take part. (See Appendix Three). The students then returned them to the researcher.

Stewart and Shamdasani (1990) emphasise the importance of group cohesiveness and compatibility when inviting focus group participants. They argue that highly compatible groups perform their tasks more effectively than less compatible groups but that compatibility does not necessarily mean homogeneity although they are related. To maximise compatibility and because females tend to be less dominant in mixed focus-group situations (Pg 43), single sex focus groups in form levels were decided upon.

There were six focus groups of 3-4 students each. This gave a representative range of form one and two students, boys and girls, a group to trial the interview schedule and a 'special interest' group of 'gifted' form two girls. All 15 students approaching the researcher were accepted, so there was no need for selection.

There were two groups comprised only of boys with four participants each, one group of form one students and one of form two students. There were two girls groups with four participants each, one group comprised form one students and one of form two students. In addition to these four groups there were two additional groups of girls. One of these comprised three form two girls, chosen because of their previous involvement in science fairs when they were in form one. They all won awards in the science fair as form one students and were perceived by the researcher as bringing a different perspective from the other students involved. The second additional group of four girls were from form one. They were the group who trialled the focus group interview schedule and the recording equipment. As the trial was successful, it was decided to incorporate the data into the study.

Decision-making regarding the structure and size of the groups was informed both by research and pragmatism. Stewart and Shamdasani (1990) suggest between six and twelve participants for a focus group interview. They argue that fewer than six participants makes for a dull discussion. However, Morgan (1988) gives benefits for small groups as well as large groups, depending on the research being undertaken. He argues that large groups are more economical and good for preliminary data collection. Small groups demand a greater contribution from each individual participant, giving potential for more in depth responses and making it easier to control the discussion. Morgan concludes that "combining both practical and substantive considerations, it appears that four is the smallest size for a focus group, and the upper boundary, although less clear cut, appears to be around 12" (Pg 44). As the focus group for this research sought in depth responses based on survey data already collected, smaller groups were deemed more appropriate. A further pragmatic reason for choosing four students per focus group was the limited focal breadth of the camera which was used for the videotaping. Four students, situated at comfortable distance from each other was maximum it could accommodate. The camera was kept in a fixed position throughout the interviews so as to provide less distraction. The restrictions within the school timetable were another reason for four participants. In order to not rush whilst completing the interview schedule with the focus group, but still fit into the school's 'blocks' of time, fewer than six participants were necessary.

The 'gifted' group, comprised of form two girls who had success in science fairs when in form one were chosen as a discrete focus group to investigate their attitudes to science. Delamont (1994) argues that too much research on girls in science has been pessimistic and negative. She posits "the time has come to approach the issue from the other end. Let us have studies of females past and present who like science, especially those who find it enchanting, and discover what went right for them" (Pg 72) and "If researchers can discover what enthuses the few, it may be possible to disseminate that enthusiasm to the many" (Pg 59).

(iii) Administration

The interviews were conducted during the school day in a spare room at Bayside school. The three or four participants in each group were seated in chairs next to each other in a semi-circle with a table or stool in front of them to support the microphone. Stewart and Shamdasani (1990) emphasise the importance of the participants being able to see each other as they contribute, but also the necessity of having their personal space unthreatened. The researcher demonstrated how the video camera worked and put the students at ease with the equipment. The researcher sat out of the camera shot, but close enough to be recorded on the microphone. At the beginning of each focus group interview the researcher explained the guidelines. These were that for each question, each student would have an opportunity to answer, then the floor would be open for general discussion. In this way, it was hoped, that the domination of the group by a minority would be avoided and advantage would be taken of the opportunity for the group synergy focus groups aim to create. This system did work well and ensured both objectives. At the conclusion of each interview, the researcher played back a small portion of the tape so the participants could see and hear themselves. The tapes were then stored in a locked steel filing cabinet until transcription. The students' results are reported in Chapter six.

(iv) Data handling

The video tapes were transcribed, read and analysed. The data were sorted into themes, not using codes as suggested by Bogdan and Biklen (1992) but by more graphic means. For each question, notes were made on each groups responses. These responses were then grouped in themes. A large chart was constructed for each question with the emergent themes across the top and the students name, gender, focus group and form level down the side. A cross denoted where a student's response fitted into the emergent themes and thus inter and intra gender, form and focus group patterns could be graphically seen. These were summarised in words in Chapter six. The researcher was cognizant of trying not to apply quantitative methods to qualitative data and also aware that an individuals response was actually a response from the group, as they had potentially been influenced by those around them. Where quotations from the focus group interviews were used in the research, the students were given participant codes, with the prefix 'FGS' for 'focus group student'. Following the code number is the number one or two, denoting form one or two and the letter 'b' or 'g', denoting whether the student is a boy or girl. This helps to place the quotations in context. For example 'FGS9.2b', denotes focus group student 9 was a form two boy.

3.6 Integration of the Data

At the heart of school culture are the values that drive it. To support the researcher's perceptions of the culture of science in Bayside school and the values which underpin it, a triangulation chart was employed to display where the supporting evidence has come from i.e. observation, document, interview, survey (Poskitt, 1989). This is presented in Chapter seven.

3.7 Limitations

The reliability of this study can be defended through its triangulated use of multiple data sources to look for intersecting lines of investigation. Its internal validity can be defended as reported evidence can be followed to allow the reader to come to the same conclusion as the researcher (Anderson, 1990). As this is a single site case study, its external validity or the extent to which generalisation is possible from it, is limited. However, as Anderson (1990) argues, it could be the first of multiple case studies through which similarities and differences are observed.

Chapter Four
Science Curriculum in the Study School

The representation of science in the school curriculum documents and the form of school science will be discussed. Three sections report on the historical context of the science curriculum, the intended and the implemented science curriculum, respectively, within the school. To analyse the intended curriculum, the science curriculum Science in the New Zealand Curriculum (Ministry of Education, 1993) together with the school science scheme were analysed. The implemented curriculum or form that science takes in the school was analysed using observation of school events, resources and content analysis of prepared lesson plans.

4.1 Historical Context of Intermediate School Teaching and Learning in New Zealand

Initially some history regarding science teaching and curriculum in New Zealand intermediate schools will be examined.

Writing in 1938, in his survey of the intermediate schools of New Zealand, Beeby stated that there were five independent intermediate schools and eleven intermediate departments. All of the intermediates had been equipped with science laboratories, with mainly physical science equipment. He observed that the laboratories tended to be copies of their high school counterparts and felt that this had the consequence of reverting to a more high school type lecture style of the 'formal' sciences. However, he did note some innovation: "A handful of teachers have broken away from the traditional laboratory course. One of these bases much of his work on native flora; another has his laboratory fitted up with a telephone system, a small lighting system and home-made crystal sets; a third states that he wants no chemicals but only an old sewing machine, a lawn mower and a collection of decrepit taps and light switches in order to centre all his science around the home" (Pg 99). Beeby complemented these teachers for their approach and comments that it is suited to the age of the children. He had two main concerns for intermediate school science when writing in 1938. The first was that the biological sciences would be ignored (agriculture was an exception to this.) The second was that "an ineffectual aping of the methods used in many secondary schools will reduce the subject to a schematic and lifeless formalism" (Pg 99). Both of these problems he saw as springing from the desire to improve the teaching of science at this level simply by the provision of more equipment.

In 1964 Watson's study of intermediate schooling in New Zealand traces a shift from the aforementioned formalism to an emphasis on nature study. Many intermediate schools dismantled their science laboratories and a special classroom for teaching science was omitted in the intermediate schools built during the early fifties.

4.1.1 1967-70 syllabus form 1 and 2

The syllabus for form one and two science from 1967-1970 (Department of Education 1967-1970) is permeated by five distinct features which distinguish it from subsequent syllabi. The lessons in the teachers' guides are very teacher-directed with verbs such as 'explain, stress, remind, and make' being prominent. The emphasis is also on the assimilation of factual knowledge. For example in lesson one on pure substances there is a list of answers which would be deemed as 'acceptable' from children. The practical activities have a teacher-directed focus with equipment and instruction laid out in a step-by-step manner. The field trips also have a teacher-directed flavour with teacher-made observation sheets directing the children's observations.

The teacher-directed nature of the instruction, as specified by the teachers' guides and the emphasis on the assimilation of facts, reflect a traditional view of science and learning. Chalmers (1982) provides a clear explanation of how 'science as knowledge derived from the facts of experience' has come to be a widely held 'common sense' view of science. These are the 'scientific facts which permeate the syllabi currently under discussion. The observer acquires some facts through repeated observations in a wide range of situations. Then using induction, they formulate a law or theory. Using this theory and a process of deduction, predictions or explanations can be made about events. Chalmers argues that this process is naive and cannot be justified because of the theory-laden nature of the initial observations. Theory of some kind precedes observation statements and the brain is selective regarding what the senses attend to. So, observation is not a secure basis from which theory can be derived. Toulmin (1981) describes the traditional view of science as 'modern science' developed from 1650 AD on and includes the assumption that science is objective and value-neutral. 'Post-modern science, which Toulmin argues had its beginnings in 1900, has brought changes in the conception of theory in science. Earlier the scientist was viewed as the detached onlooker; in post-modern science the scientist is viewed as a participant in the process.

A major influence in the revision of our view of science has been the work of Kuhn (1970). Kuhn espouses the revolutionary nature of scientific progress. Instead of one method of undertaking scientific investigation and sets of principles being handed down through centuries (cumulative science), Kuhn views science following the chaos of 'pre-science' with a period of 'normal science' where scientists work within a paradigm. That is a set of general theoretical assumptions used to account for behaviour observed in experiments. Then when scientists can no longer use the paradigm to answer questions posed of it, there is a period of crisis where they revise their thinking before working on in a revised paradigm and a new period of 'normal science'. However, the teachers' guides 1967-1970 reflect the focus on factual principles and the idea of the scientific method when Toulmin posits that post 1900 it is acceptable to have more than one correct way to carry out scientific investigation. The role of the teacher, in the teachers' guides, it appears, is to transmit knowledge and model the scientific method.

4.1.3 1978 draft syllabus F1-1V

In 1978 a draft science syllabus for form 1-1V (Department of Education, 1978) was introduced which has a change in thrust and some additional emphases from those in the 1967-1970 syllabus. There is a new emphasis on more pupil responsibility for learning as teachers are encouraged to recognise and use children's current interests in designing the programme. The increased emphasis away from factual knowledge and towards process skills is evident in the syllabus. It stresses observing, measuring, classifying, inferring, predicting, hypothesising, experimenting, presenting and analysing the results but it gives the learner no credit for having any prior knowledge of the topic under study.

4.1.4 1989 draft syllabus F1-V

The 1989 Draft Syllabus for form 1-V science (Department of Education, 1989) marks a dramatic shift in the philosophical underpinning of science education. This syllabus introduces new thrusts regarding the nature of science where children are encouraged to make use of hunches and guesses as well as logical thinking. This acknowledges knowledge as a human construction and not as a given law. The complementary notion regarding the nature of science education also changes as learners are seen as starting with preconceived ideas. The stated aims of the syllabus reflect an even more learner-focused orientation. Accompanying these ideas are 'new' notions of the role of the learner and the teacher. The key components of learning in science are seen to be "contexts", out of which arise learning experiences and content knowledge. There is an increased emphasis on technology and some positive action for female and Maori students.

This syllabus states that the learner brings to science lessons their own explanation of the world. This reflects the influence of the theory of constructivism, a theory promoted in the research of the Learning in Science Project (Osborne and Freyberg, 1985). When writing the 1989 form 1-V science syllabus, the syllabus committee reviewed the 1978 form 1-V syllabus and took into account, among other inputs, the findings of the Learning in Science Project(s) on how children learn science. Osborne and Freyberg were co-directors of this project based in the University of Waikato (1979-1984). Their main findings which were to influence the 1989 syllabus are as follows:

i. From a young age children have meanings/beliefs for concepts or words in science.
ii. These are often different from the meanings/concepts that will be latent in the science lesson.
iii. The child's concepts are often strongly held and remain unchanged, even after science teaching.
iv. Children often build their own purpose for the science lesson based on their prior ideas and then try to make sense of the lesson based on this.
v. There are may opportunities for mismatches between the scientific concepts of the teacher and the intuitive ideas and language of the learner.

4.1.6 1993 science curriculum

The 1993 science curriculum drew on science curricula in operation at the time of its development. This is a further manifestation of the Learning in Science Project, Osborne and Freyberg's (1985) ideas which influenced the 1989 form 1-V science syllabus. In order to understand the nature of their ideas and their influence on the 1993 curriculum, one needs to understand the dominant forces in the science education landscape of the time. These forces shaped the intended curriculum of this study.

Biddulph and Carr (1992) trace developments in New Zealand science education from the early 1980's to the early 1990's. They argue that in New Zealand in the early 1980's four major problems hindered science education. Teachers lacked confidence to teach science, because, in their view, it was viewed as a body of information that was difficult to understand. Little science was being taught at the primary level, children were bored by science lessons and they often obtained unintended ideas from science lessons. To address these issues the Learning in Science (Primary) Project (1982-84) explored ways of overcoming these problems. Biddulph and Carr (1992) argue that this group sought a goal for primary science education and stated that "the main point of primary science education is to help children make better sense of their world" (Pg 192). The Learning in Science Project then formulated a teaching approach to put their ideas about how children learn in science into practice. This 'interactive teaching approach' recognises that children have existing ideas about scientific concepts, and are able to and should generate investigable questions as a base of their own enquiry during science lessons. Children's questions are therefore "accorded a significant role" (Pg 193). The 'Interactive Approach' consists of five components and prescribes six teaching roles for the teacher. "The components are:

- a preparation time for the teacher
- exploratory ideas to raise questions in the children's minds.

- eliciting children's questions (and prior ideas)
- assisting children to devise and carry out investigations
- helping children reflect on and share their findings.

The teaching roles are as

- a stimulator of children's curiosity
- a challenger of children's ideas
- a resource person
- a senior co-investigator
- a provider of a non-threatening classroom environment
- a co-evaluator" (Pg 194).

The theory which underpins this approach and the focus on children's ideas is constructivism. Solomon (1992) in her historical review of various teaching methods in science summarised three central tenets of constructivist theory. The first is that children are seen as having naive ideas of scientific concepts. The second is that children cannot accept orthodox knowledge which is at odds with these ideas. Third and finally, such a view of learning has as its underpinning a view that scientific knowledge is a human construction and not "a series of God-given laws revealed through the experimental 'verdict of nature'" (Solomon, 1992, Pg 12).

While there is no explicit reference to underpinning pedagogical or epistemological theory in the 1993 science curriculum, two features in particular indicate a foundation in constructivism; the naming of the 'strands' and the contents of the 'enhancing achievement' section.

The curriculum is organised into 'strands', including : Making Sense of the Material World, Making Sense of the Physical World, Making Sense of the Living World and Making Sense of Planet Earth and Beyond. This reference to 'making sense of 'echoes the goal for New Zealand science education, articulated by the Learning in Science Project, summarised in Biddulph, and Osborne (1984) and implies a child actively interacting with a context and constructing meaning.

The 'Enhancing Achievement' section of the 1993 science curriculum also indicates foundations of constructivism. The purpose of this section is to provide direction for learning in science. It is suggested that students learn best in science when the:

> "Students have the opportunity to clarify their ideas, to share and compare, question, evaluate, and modify these ideas, leading to scientific understanding;"
>
> "Teachers and students work within a supportive atmosphere of mutual respect where all the experiences, ideas and beliefs, which students bring into the learning situation are acknowledged as a basis of learning;"

" scientific knowledge, skills and attitudes are first introduced in contexts which are relevant and familiar to the students" (Pg 10).

These suggestions relate directly to Osborne's (1982) thoughts on necessary components in lessons to produce conceptual change when using a constructivist framework:

"* Teachers' lesson preparation leading to their understanding the relevant scientists' views and the children's views;

* Students becoming familiar with the context of the ideas, by experiencing the phenomena to be discussed;
* Students clarifying their own views of the phenomena being discussed;
* Students presenting their own view as part of a discussion of different views and understandings;
* Students and teachers appreciating the views of others to create a supportive learning environment in which personal ideas of students are valued as worthwhile contributions to the learning experiences of the class;
* Changing the status of the different view points, so that the students will see the scientific viewpoint as more intelligible, plausible and useful than their own, This usually involves contrasting the students' ideas with the desired view.
* Elaborating the new ideas, by students exploring similar and new examples of the phenomena to help them fully appreciate that new ideas are intelligible, plausible, fruitful, and can be linked with more ideas in long-term memory" (Pg 31).

Therefore a foundation of constructivism can be seen in the 1993 science curriculum. A more detailed outline of the curriculum will be furnished in Section 4.2.

However, constructivism has its critics and the 1993 science curriculum has not been implemented as those with responsibility for it in New Zealand would have hoped.

Solomon (1994) has critiqued the rise of contructivism, particularly how a theory about children's ideas has become a teaching method. She traces the seeds of constructivism in the work of Piaget who interviewed children to find out their ideas about natural events. However, Solomon points out that the outcomes were valued as representative of cognitive development, not as examples of mature scientific thought. She states that Driver and Easley's (1978) article "created the tools for the accelerated rise of constructivism" (Solomon, 1994 Pg 3) as they coined the phrases 'interpretive models' and 'a lternative frameworks' for children's naive scientific notions. Consequently they were ascribing more scientific value to children's ideas. Therefore Solomon argued, misconceptions had been redescribed as coherent bodies of thought, and the focus had turned to children's own ideas. She traces three new aspects of constructivism which

emerged in the early 1980's, the theory of personal constructs, the notion of children's science and the social construction of knowledge.
She argued that researchers in New Zealand at that time took up personal constructivism and embraced children's science until the two movements had little to distinguish them from each another. Then in New Zealand, as elsewhere, an 'instructional path' was sought using constructivist ideas. However, Solomon argued that "investigating the social interactions between pupils, or between pupils and teacher, may illuminate the pupils' alternative frameworks or even their development, but cannot be relied upon to generate changes in one direction rather than another." (Pg 11).

Matthews (1995) is another researcher who expresses concerns regarding the ability of constructivist instruction to effect conceptual change. He argues that there are some concepts which it is not possible to let students investigate and discover for themselves and that teacher- directed learning and transmission of knowledge from teacher to student is the only option. He also despairs of the lack of science content knowledge held by primary teachers, and the lack of emphasis for entry to Colleges of Education of them needing it. However, Osborne's earlier writing does emphasise the importance of teacher knowledge of scientific concepts. The first component in a lesson designed to effect conceptual change is; "it is important that the teacher understands the scientists' views and the children's views" (Osborne, 1982, Pg 27) Then, towards the end of the lesson, " to produce conceptual change pupils not only need to appreciate alternative views but to perceive these as more intelligible, plausible and useful than their present viewpoint" (Pg 28).

4.2 National Curriculum for Intermediate School Science

Within the New Zealand Curriculum Framework (Ministry of Education, 1993a), science is one of seven 'essential learning areas'. Each of these learning areas has a curriculum statement which defines the learning principles, achievement aims and objectives which all New Zealand schools are required to follow. There are eight 'levels of achievement' spanning 13 years at school. For each level there are achievement objectives given. Although the framework suggests that the majority of intermediate school children will be working at level four, it is emphasised that not all students of the same age will be achieving at the same level. From the achievement objectives teachers are expected to derive specific learning outcomes for their school's students. It is against these which a student's progress is assessed, using a range of assessment procedures.

The science curriculum statement is entitled Science in the New Zealand Curriculum

(Ministry of Education, 1993b) and "provides a framework of learning in science for all students" (Pg 7). The aims and major emphases in the document will be discussed initially, then Bayside's science scheme examined to see how the school has interpreted the framework. First, however, the suggested relationship between the science curriculum document and the school schemes in general will be discussed.

4.2.1 The science curriculum and its relationship to school schemes

The national curriculum is intended to provide a framework for planning a school's science programme.

" Teachers, with the support of their school community will use it to develop their school science scheme. It will be the school science scheme that sets the specific learning outcomes, derived from the achievement objectives, and structures the learning experiences of classes and individuals" (Pg 21).

Although sample learning contexts, possible learning experiences and assessment examples are provided in the curriculum, they are not intended to be prescriptive but are provided "to indicate the scope and depth of learning" (Pg 21). However, it is stated that the learning contexts chosen should be identified in the scheme and/or unit outlines, therefore the statement could be interpreted as being prescriptive to a degree.

Therefore there is flexibility in implementation of the national curriculum and in order to achieve the document's aim that "this will result in each school providing a unique science programme that recognises the particular character of their student population, that make effective use of local resources, and that fits in with decisions relating to the whole of the school curriculum" (Pg 21).

4.1.2 Outline of the science curriculum

The science curriculum is shaped around four contextual strands and two integrating strands which focus on science process skills. In each strand for each level, sample 'learning contexts' are given, 'the rocky shore', for example in the strand 'making sense of the living' world. Accountability and achievement are important in this document as achievement objectives are given for example level four, material world achievement objective three states students must be able to : investigate and describe ways of producing permanent and temporary change in familiar materials. In addition, ideas are given regarding how to enhance achievement in science learning.

(i) Underpinning theory

As argued earlier in this chapter, the pedagogical and epistemological theory which underpins the science curriculum indicates a foundation of constructivism.

This has been argued as evident in the naming of the contextual strands, for example, 'Making Sense of the Living World', and in the content of the 'Enhancing Achievement' section of the curriculum, in which several direct quotes from the work of the Learning in Science Project authors can be seen.

(ii) Aims

The curriculum provides twelve general aims for science education in New Zealand. The first three aims of the science curriculum deal with developing the knowledge for understanding science, the skills for investigating and the scientific attitudes on which investigation depends. A further five aims could be described as emphasising the constructed and tentative nature of science and its applicability, its influence on and how it has been influenced by people. This reflects a new, more post-modern attitude to the nature of science (Chalmers, 1982). The importance of scientific knowledge and skill in decision making is reflected in two aims. The final two aims emphasise the importance of ensuring a future scientific community and that people have the interest, knowledge and skills to take up scientific careers. This reflects the promotion of science and technology for research and development by government (Beattie, 1986).

In addition to these general aims, achievement aims are presented at the beginning of each strand in the science curriculum. They provide the themes that link the achievement objectives of each level. This linkage is intended to promote continuity through all levels of schooling. One could interpret this as a mechanism for increasing accountability of teaching and measuring standards as there are specific graduated objectives for a child from when they enter school, until they leave. For example in the physical world strand, level one, students share and clarify their ideas about physical phenomena and by level four students investigate and group common materials in terms of properties.

(iii) Achievement enhancement

Achievement enhancement appears to be a concern of this curriculum as it has furnished guidelines to provide direction for learning in science. This concern is based on both emancipatory and economic concerns. Desires are articulated for students "to continue their participation in science education beyond the years in which it is a required school subject" (Pg 8, Ministry of Education, 1993b) and, to promote students who will contribute as "informed members of society and as productive contributors to New Zealand's economy and future" (Pg 9). This reflects the influence of the New Right who espouse the view that "education is fundamentally a vehicle for the acquisition of marketable skills (and hence wealth and status) (Pg 12, Lauder, 1990). Integral to this view is also an emphasis on the individual and competition.

(iv) Curriculum structure

The content of the Science Curriculum is presented in six 'learning strands', four contextual strands and two integrating strands.

The contextual strands are:

• Making Sense of the Living World

• Making Sense of the Material World

• Making Sense of the Physical World

• Making sense of Planet Earth and Beyond

Two further strands are described as integrating strands which are to be interwoven with the contextual strands. They are:

• Making Sense of the Nature of Science and its Relationship to Technology

• Developing Scientific Skills and Attitudes.

The science curriculum emphasises the selection of relevant contexts for learning science, particularly that an idea should be introduced in a familiar context and later developed in a challenging context. The document gives a range of suggestions of contexts for each strand at each level.

A range of learning experiences are also included. The document argues that "the choice of appropriate experiences will depend on a number of important variables. These include the nature of the targeted achievement objectives, the class composition, the community of which the school is a part, the teachers' and the students interests, topical events and the time of the year" (Pg 8).

In each contextual strand, there are many suggestions given to teachers as to possible learning contexts to set their teaching in, for example when' making sense of the physical world' a possible learning contexts are 'fun with wheels' and 'technology all around'. Besides giving the impression of being helpful and making the curriculum more user friendly, this also helps channel teachers into the constructivist teaching the curriculum promotes. It suggests 'contexts' rather than 'topics' to denote broader fields of study and a more child-investigative approach than a teacher-transmission model. Possible learning experiences for making sense of the physical world include working in groups to construct a simple circuit to light a model house or finding which metal from a given sample would be best for making a saucepan. These learning experiences or activities where children are actively involved either independently or as part of a group, are central to this curriculum. The integrating strand 'making sense of the nature of science and its relationship with technology' also contains achievement objectives, possible learning experiences and assessment examples. The other integrating strand of 'developing scientific skills and attitudes' also has learning experience examples given.

Suggestions are also provided of a variety of ways to assess the students' learning. The presence of assessment examples signifies the importance of accountability and the influence of the New Right (Lauder, 1990).

(v) Science for all

It is argued that "an inclusive curriculum that recognises the perspectives of a particular group of students can enrich education in science for all students" (Pg 11). The groups targeted specifically for inclusion are girls, Maori, students with special abilities in science and students with special needs and science.

It is posited that girls should have opportunities to learn science that they value with nonsexist materials, using their language strengths while working co-operatively and having their equal share of the teacher's time. There is also direction to examine the constructed and relative nature of science, reflecting a postmodern view (Toulmin, 1981). Likewise Maori students should have opportunities to learn science within Maori contexts using Te reo Maori resources which are non racist and using their preferred learning and communication styles.

When creating an inclusive curriculum for students with special abilities it is advocated that teachers should provide open ended activities to encourage students' lateral thinking and use of higher order thinking skills. A co-operative approach could be part of this. At the same time they should have opportunities to share their ideas with others of similar ability and have their abilities in science valued by their wider support network, for example their families.

Children with special needs and science should have support from those around them also and programmes and resources to enable them to parti cipate as fully as possible.

4.3 Study School Scheme for Science

The Bayside science scheme (Bayside School, 1995) will be considered in relation to each of the points discussed in 4.1.2. Bayside school has a teacher with responsibility for science who co-ordinates science delivery. There is also science curriculum committee. The scheme outlines its goals and learning outcomes for science at Bayside school, and discusses suggested teaching approaches. In addition it outlines the prepared 'units' of work which the teacher with responsibility for science has prepared to support teachers in science. They consist of lesson plans and resources which were designed, tried and used by teachers and children five years before the new curriculum. These units will be analysed in more detail later in this chapter.

4.3.1 General aims

The espoused 'programme goals' of the Bayside science scheme (1995) are:

1. " To ensure that all children receive high quality and equitable science teaching so that they achieve to the best of their ability in science", (Pg. 2) thus implementing 'science for all' ; (4.1.2[v]).
2. "To devise assessment activities that provide sound information for determining a child's overall level of achievement." (Pg. 2) reflecting the focus on assessment in the national document (4.1.2[iv]); and two which bear no relation to the curriculum,
3. 20% of Form One children to participate in the Science Fair.
4. To win five sections in the North Harbour Science Fair and seven Highly Commended placings.

The final two goals reflect Bayside's concern with the involvement of outside schemes such as science fair. Encouragement of at least 20% of form one children to enter the science was made. The emphasis on winning prizes in science fair competitions outside the school could be related to the effect it has on the school's image in the community. The school has consistently had a strong public image in science by winning many prizes in the regional science fair. This could be argued as part of the individualism and competition of the New Right climate.

4.3.2 Achievement enhancement

Bayside's scheme addresses achievement enhancement by outlining recommended 'Planning Requirements' and 'Teaching Approaches'.

Under 'Planning Requirements' it is stated that a standard form must be used to set out ? planning, called the 'science unit planning sheet'. The "planning sheets are designed to show and ensure that each unit: enables children to work at their own level, enables each child's 'level' to be known before the unit commences and uses an interactive methodology" (Pg 2). 'Interactive teaching' is a term used to describe the constructivist classroom teaching methods proposed by the Learning in Science Project (Primary) (1984, Biddulph & Osborne). The planning requirement section goes on to explain how to assess a child's level of knowledge prior to instruction and how to group the children on the basis of that knowledge. Then, the aim is that activities are designed for the range of levels. The school assumes that planning sheets will 'ensure' that interactive teaching will take place because of the appropriate headings on the page. One could argue this assumption is naive as such teaching depends on a teacher's level of familiarity with the process.

Under the heading 'teaching approaches' the scheme espouses an interactive teaching approach which should be "characterised by the following sorts of indicators:

- Students establish what they already know or believe about a topic or area of investigation.
- Students develop a proposition or hypothesis to investigate using 'fair testing' method.
- Students are able to describe what they have investigated and what they know or believe.
- Students challenged and expected to achieve.
- Positive relationships between teachers and students.
- Well established classroom routine.
- Learning objectives clear to teacher and students
- Assessment of each students' learning is ongoing, diagnostic and shared with the students.
- Pupils will be involved in the assessment and evaluation of their own work" (Pg 4).

Although the interactive approach is acknowledged as far as students establishing what they already know about the topic and developing their own hypotheses to investigate, what is missing from this scheme that has emphasis in the national science curriculum is the focus on using new skills and ideas first in a familiar context and then later in challenging situations. This scheme has added 'well established classroom routine' (Pg 4) and while 'learning objectives are clear to both teacher and student' (Pg 4) there is no mention of flexibility in teaching styles or the importance of students seeing the usefulness of science to themselves and to society. This suggests the school reinforcing a formal and structured approach to science teaching.

4.3.3 Curriculum structure

In the Bayside school science scheme, the strand organisation is that indicated in Table 4.1 below. According to the school scheme at least one 'topic' from each contextual strand should be covered each year. In 1995 the school operated in a three term year, so teachers chose the term during which they covered two science units. There are four objectives for each strand, as in the curriculum, and these objectives are split randomly between forms one and two. The numbers indicate which specific objectives will be covered in form one and in form two. The word 'topic' indicates which contextual strand will be covered, although the words 'contextual strand' do not appear on this document. The scheme implies that a 'topic' is a contextual strand, which is incorrect. 'Topics' could be subsets of contextual strands, similar, although more narrow than a learning contexts. There is no mention of learning contexts.

Table 4.1

Science topic overview*

Topic	Aims and Objectives Form one Objectives	 Form Two Objectives	Prepared Units#
Living World	1 & 2	3 &4	None
Physical World	3&4	1, 2 & 4	Form One - Electricity and Magnetism Form Two - Radiant Energy
Material World	3 & 4	1 & 2	Form Two - Chemistry Unit in Lab
Planet Earth and Beyond	3	1, 2 & 4	None
Science and its relationship to technology	Form one topic only 1, 2, 3, 4		Technical Lego
Science Fair	Able Form One Children (20%) at teacher discretion All Form 2 Children		

Source - Bayside Science Scheme.
 # Units prepared by the teacher with responsibility for science are available for use by all staff.

Although there is no reference in Table 4.1 to the integrating strand of scientific skills and attitudes, the text of the scheme states: "In both years the achievement aims for the integrating strands will be evident in the majority of units taken and progress through levels of integrating strands assessed" (Pg 2). The other integrating strand "making sense of science and its relationship with technology" is present as a 'topic' at the form one level on lego. This indicates a misunderstanding of the role of this integrating strand. The curriculum states "the objectives of this learning strand are to be gained through the content and context of the other learning strands" (Pg 25). It is also noted form Table 4.1 that there are no prepared units for the living world or for the planet earth and beyond. This is because the teacher with responsibility for science felt that teachers required more support in the physical and material world areas. In addition to this, physical science was his particular area of personal interest.

The Bayside scheme states that each child receives approximately 40 hours of active science learning time each year or 10 hours per contextual strand. The programme is also supplemented with approximately a further 20 hours spent by most form one and two children on science badges (the NZ Science Teachers Science Badge Programme) and 20 hours by form two and some form one children on preparation for the science fair. The national curriculum does not outline minimum time requirements for the teaching of science. However all contextual and integrating strands are expected to be taught. In this regard, one could argue that science fair and science badge work, much of which is focused on science investigations could fulfil the integrating strand of developing scientific skills and attitudes. As indicated above, at Bayside, according to the scheme fifty percent of the time is spent on science study with regard to the document and the other fifty percent on science fairs and badges. In the ERO report 'Science in Schools - implementing the 1995 science curriculum', (Education Review Office, 1996) it was reported with regard to practical science activity "In 10 schools there was considerable student involvement in science fair activities which, in some cases, dominated the practical programme. It is unlikely that a school will be delivering a balanced science curriculum in situations where science fair activities dictate a student's practical science programme" (Pg 16).

Possible learning experiences are not detailed in the scheme but are included in Unit Plans, as the New Zealand curriculum document permits (Pg 21).

The scheme states that "each teacher follows the school topic overview to choose the context for each strand for the year" But neither the word strand nor context is mentioned in the topic overview, Table 4.1. It goes on to say " They then either take the school unit on the context or design their own and then complete the 'science unit planner' sheets in the appropriate sequence" (Pg 2). This could be indicative of a science programme which was designed to be 'topic-based' before the new curriculum now striving to 'convert' to the new terminology without the understanding of what it means and what its implications in practice are. In addition, although the rhetoric makes the prepared school units sound optional, in reality all staff complete them with their class, in preference to designing and resourcing their own.

4.3.4 Assessment

As in the science curriculum the Bayside science scheme suggests that teachers should find out what their student know and think before the unit begins as in the Learning in Science Project 'interactive teaching'. This is referred to as 'before views'. The scheme also states that importance is placed on each student developing their own learning objectives, usually out of the 'before views' assessment. Teacher questioning and modelling, student self-assessment, peer-assessment and science diaries are also suggested in the scheme as assessment methods.

Summative assessment, according to the Bayside science scheme is completed at the end of a prepared unit of learning and is used for judging whether the children have acquired the desired or expected level of curriculum-relevant understanding. It is stated that "At the end of each unit a formal post-test is given that has been designed and trialled or approved by the science committee. This will assess knowledge and where possible skills and attitudes across levels 2,3,4, and 5. Where there are achievement aims included in the unit from the "Nature of Science and its relationship to Technology" strand these will also be assessed (Pg 6). The formal post-test is a written test. The information is then collected and entered into a computer in the office in order to monitor pupil progress.

The scheme reflects a range of assessment techniques suggested in the national science curriculum, although it also requires formal post-tests which are not part of the national curriculum, for prepared units.

4.2.4 Summary

The scheme is a composite of old and new. In its rhetoric it reflects most of the constructivist, interactive science emphases inherent in the new science curriculum. However, in its inconsistent use of terminology, in Table 4.1 and in the body of the scheme text, the understandings of the terms 'contextual strand' and 'context' appear shallow. In line with this conservative approach is the formal emphasis in the Bayside scheme on summative assessment in the form of the formal post-test. Also consistent with a traditional approach is the exclusion of the science curriculum's emphasis on using new skills in familiar contexts first and then in challenging situations as well as seeing science as relevant to themselves and society.

4.4 Delivery of Science in the Study School

This section outlines how school science is delivered at Bayside school. The description is compiled from document analysis and informal observation.

4.4.1 Management of science

The teacher with responsibility for science has normal classroom teaching responsibilities and in addition provides support to the other classroom teachers in this subject area. The teacher is an experienced male who is accountable to one of the deputy principals who oversees all curriculum delivery in the school to ensure that scheme requirements are being met. The science scheme is jointly developed between the deputy principal with responsibility for curriculum and the teacher with responsibility for science. All staff members belong to at least one curriculum committee. There is a science curriculum committee of five teachers, four female plus the male teacher with responsibility for science. The teachers were coerced to join this committee as no one had a genuine interest in the area. The science curriculum committee has meetings on a needs basis. Whilst one of the espoused roles of the science curriculum committee was to approve unit post-tests, in reality the teacher with responsibility for science did this. The actual role of the committee is to support the teacher with responsibility for science, especially for the organisation of the science fair.

Methods of communication with parents and guardians with regard to school science are described below.

(i) School reports

In 1995, Bayside School designed and printed new school report forms. In science the classroom teacher is required to provide grades and comments in each of the contextual strands of the science curriculum i.e. the Material, Living, Physical Worlds and Planet Earth and Beyond. The integrating strand of scientific skills and attitudes is commented on in the report under the title 'investigation'. A grade and comments are given for the child's investigation work in class, in science badges and in the science fair.

(ii) School newsletters

Every Bayside school newsletter includes a report on what is happening in curriculum areas. The science strand under study each term is noted for the parents and units currently being taught in the science laboratory are also noted.

Leading up to the school science fair, the newsletters detailed what support was being offered to children to aid their completion of the projects, for example the opening of the computer room and science room on a Saturday morning for extra help. Parents were also reminded about the science fair parent evening and a report was furnished after the evening (See Appendix One). 'Milestones' of where children should be up to at certain points were reported in newsletters. Through these communications parents were encouraged to "allow time in you diary to visit the science fair - bring friends and grandparents". Through the messages in the newsletter, it was emphasised that the project was not being left to the parents, although it was primarily a homework task, but that the school was actively monitoring progress and providing support and resources.

4.4.2 Regular teaching support

Coverage of the science scheme is monitored by the deputy principals when they check teachers' planning. For some 'topics' there are units prepared and set up by the teacher with responsibility for science. The 'topics' for which these are provided are listed in the scheme (Table 4.1). As all of the prepared units are taught in the science laboratory and all other science units are taught in regular classrooms, there is some pressure to use the prepared units.

Bayside has two large shelves of science related books in the staff library. They are a mixture of what could be termed 'books about science knowledge' and 'books about science teaching process', although the former outnumber the latter. There is a balance between books pertaining to the physical sciences and life sciences. There are also four enlarged picture books on science-related topics. Recently six posters were purchased to support studies on the solar system, mangroves, and volcanoes. In addition some new science books for the children's library were purchased.

The main vehicle through which teachers at Bayside school receive support in their science teaching is the prepared units of work, taught in the science laboratory, and therefore analysis of this setting and the lessons themselves provides information as to the values underpinning science at Bayside school.

(i) The science laboratory

The science laboratory was built in 1958, and is typical of the laboratories modelled on their secondary school counterparts. It contains an office and workshop space for the person in charge of science and a storeroom for equipment. When the school opened it was used as a science room until 1960 when it reverted to a classroom teaching space until 1985 when it became solely a science teaching space once more. These changes occurred as a result of roll fluctuations and changing Department or Ministry of Education policies regarding numbers of 'allowable' teaching spaces. In 1993 the Ministry of Education started counting the space as a regular classroom teaching space again, although Bayside School built another classroom from fundraising money so they could keep their science teaching space.

The original 'Science' name plate on the door of the room denotes its role. The room is dominated by ten benches; although movable most of them are in parallel rows and facing the 'demonstration bench' at the front of the room. On the right hand side of the room are a row of sinks and three empty fish tanks. Under the bench are rows of cubbyholes filled with sheets of paper, pieces of wire and electrical equipment. On shelves at one side are rows of test tubes and other glassware. Science Fair projects from previous years lean against the wall, with one Van Der Graf Generator, a project from 1995, displayed on a bench. In the room at the back of the science laboratory there are shelves crammed with test tubes, flasks, bungs and tubing. There are two long shelves filled with amber and plastic bottles of chemicals, labelled: Potassium iodide, calcium hydroxide, ammonium chloride. Also featuring are boxes of electric motors, compasses, a hammer and nails, a box of straws, plastic plates, food colouring and dish washing liquid. In summary, a mix from accurately named chemicals to handyman's equipment. At the entrance of the science laboratory an adjacent room leads off. This acts as an office/workshop area. Behind the door is a bag of peat moss and a hydroponic frame. A pile of 11 Dick Smith Electronic boxes are prominent as are shelves of other electronic equipment. There are boxes in which to keep insects alive, a bucket of sand, a box of rocks and many shelves with Education Department units and science text or source books suitable for adults. The resources in the science laboratory reflect an orientation towards t he physical sciences. Although fish tanks and insect boxes were included, they are not in use. From the positioning of benches in rows facing the teacher's table and the absence of children's work other than Science Fair projects, one could deduce a teacher-directed focus to lessons here. However, responsibility has been assigned to a staff member to provide displays, which indicates an attractive environment has some priority.

(ii) Prepared science lessons

There are three prepared science room units. The lessons are aimed to be sequentially developed within the units. Each activity is trialled by the teacher with responsibility for science before being made available to the general staff. If a teacher opts to teach a prepared science room unit, the unit plan is provided for their information many weeks in advance of the lessons. The unit plan includes objectives to be taught and assessed, sometimes a pre and post-test, individual lesson sheets which takes the teacher and student through each lesson step by step. The teacher with responsibility for science runs a workshop session, for teachers, in the science laboratory every Monday at lunchtime. During these times he teaches the teachers how to deliver the prepared lessons, provides clarification on lesson content and equipment manipulation.

When the teachers aim to take a lesson from these series, they 'book' which specific lesson they require on a timetable in the staff room. The general rule is not more than one lesson a week to allow a fair share of the resource. There are then student monitors who are pupils of the school who collect the sheet and set up each lesson before the block of time starts. They are trained to know what pieces of equipment and worksheets go with which specific lesson of each unit. Therefore all the appropriate task sheets and explanations are provided in writing for each student with an accompanying box of equipment. After each lesson the monitors clear the equipment away and set up for the next lesson.

Nature of the prepared science lessons.

A detailed discussion of one unit follows. Extracts from this can be found in Appendix One as well as detailed analyses of the other prepared units.

Form Two-Material World Prepared Unit: "Chemistry"

In this section the unit objectives, content and activities as well as the end-of-unit test are discussed.

Unit Objectives:

This unit is comprised of seven lessons. There are two A4 pages of objectives provided. The four 'specific achievement objectives' come from the national science curriculum and include page references for teachers to consult the original document. Featuring in these objectives are the words 'familiar materials', 'common materials' and 'everyday situations'. In addition to these there are three adjuncts. The first is a list of laws that the students should know e.g "Air is a mixture of gases - nitrogen, oxygen, carbon dioxide and water vapour" Chemistry unit, p1). The second is a list of skills including mastering filtration, magnetic separation, distillation and devising an experiment to test a hypothesis.

Finally, under the heading of 'attitudes and transfer of knowledge' it is suggested that the students should "relate separation techniques studied in the classroom to everyday situations" (Chemistry unit p.2).

Lesson content and activities:

The activity types were either listed as 'activities', 'problems' or 'experiments'. (See Appendix One). However, the name given to the activity type did not appear to distinguish between the activities; for example, the 'activity' of chromatography involved following a set of instructions as did the 'experiment' to observe dissolving. In each case step by step instructions were given as to how to do the activity, solve the problem or carry out the experiment therefore requiring little active thinking on the part of the student (see lesson sheet for 'flotation and evaporation' in Appendix One) The distillation activity was slightly open ended in that it required the student to make a list of ways to improve the system, having given a diagram of how to set up the experiment initially, but in the remainder there was no opportunity for the students' own investigation. In only two of the seven lessons was knowledge applied to what could be viewed as a 'child's world' (felt pens and cake baking), despite the focus provided in the objectives. In the remainder, the context and the activities are removed from most children's experiences, for example heating copper sulphate and sodium thiosulphate (lesson two) and separating a salt water and sawdust mixture (lesson four). Analogy was employed in two lessons, likening chemical change to cake baking and separation to cloud formation. Three lessons feature clean-up instructions, while safety instructions are in four lessons and appear twice in two lessons. Key vocabulary during this unit includes: separation, particles, chromatography, chemical change, solute, solvent, evaporation, distillation, copper sulphate and sodium thiosulphate. Instructions of what to write in the science exercise book were included in five of the seven lessons. The equipment used would be that found in some intermediate schools of the same era and in secondary schools, glass measuring beakers and jars of chemicals (with the exception of the felt pens). Three lessons out of the seven employ 'teacher demonstrations'.

In addition to the seven lessons in the unit, provision is also made for an extra 'scientific investigation'. The unit plan explains : "The Mini Scientific Investigation task would give scope for the more able students who have the necessary self-discipline to carry out independent investigations"

(Pg 2). This is a totally open-ended investigation opportunity with no guidelines provided.

End of unit test:

The end of unit test is the assessment of student learning in the prepared units. The test marks are divided up as follows:

Section 1. Knowledge: 6 marks
Section 2. Application of Knowledge: 5 marks
Section 3. Classifying: 7 marks
Section 4. Vocabulary (Communication): 5 marks
Section 5. Process skills (Devising an experiment): 5 marks

While it may appear that a balance of knowledge, application and skills are being assessed; upon closer scrutiny of the test content, Sections 1, 2, 3 and 4 require factual recall. Section 5 requires children to "draw a diagram" showing distillation, decanting, filtering and chromatography, hence they are asked recreate the experiments completed in class, not actually devise an experiment or process information but also recall.

In all three prepared units children are encouraged to discuss their ideas with each other through some of the worksheets which encourages negotiation of meaning and active sense making, as do the hands-on activities. The teachers are supported not only in the provision of the children's worksheets and equipment being sourced, organised and set out for them, but also have the 'help sheets' in some cases to help provide a firmer knowledge base. The activities provided within the lessons, while generally not encouraging independent investigation in themselves, do provide a knowledge base from which such investigations can take place if individual teachers choose to facilitate them.

However, it could be argued that the form two physical and material world units entitled 'Radiant Energy' and 'Chemistry', respectively, are not set in a child's context, nor do they use everyday situations, common or familiar materials as the science curriculum objectives states. The activities themselves allow minimal scope for individual investigation. The lessons, while having a large hands-on component, concentrate on knowledge to the exclusion of process skills. The end of unit test rewards recall of the unit's vocabulary and set experiments rather than understanding or the application of the knowledge gained. However, the structured nature of the tasks, the prevalence of safety instructions, recording instructions and teacher demonstration, increase the manageability of the lessons for teachers, as do the 'help sheets'. The form one Physical

World unit entitled 'Electrical Energy' also focuses on guided, hands-on experiences for the students, but gives them slightly more opportunity to test their own thoughts within the structure of the lesson. The end of unit test also appears more balanced when compared to the form two unit tests in terms of assessing factual recall and application of knowledge gained. As the activites and lessons generally do not give much idea of the application of this knowledge to the world, teachers, with their traditionally weak background knowledge in the area may have difficulty in demonstrating or explaining the application of these lessons to the 'real world'.

4.4.3 Education Outside The Classroom (EOTC)

At Bayside school, the organisation of 'out of classroom' science events and activities reflect the school's beliefs in manageable packages of investigation and the ethos of competition. The organisation of school events for participation in the North Shore and New Zealand Science Fairs, Science Badges, the New South Wales Science Competition and the BP Problem Solving Challenge will be discussed in turn.

(i) Bayside, North Shore and New Zealand Science Fairs

Participation in the school science fair is compulsory for all form two students at Bayside school and optional for form one students. The entrants in the school science fair are judged and a selection of the best from each category represents the school at the regional Science Fair. From there, exhibits are chosen for the New Zealand Science Fair.

In 1995 the school science fair was held in the last week of June. However, each year preparations begin well before then. Approximately four weeks into Term One two 'extension groups' are selected from form one and one is selected from form two to work more intensively on science fair projects. These groups are established with the aim of extending the more able students and winning prizes in the regional science fair. Students selected for these groups are chosen on the basis of interest in science and general academic ability. The groups are selected by the teacher with responsibility for science and involve fifteen form one and fifteen form two students. The teacher with responsibility for science teaches the form two science extension group and the researcher teachers the form one science extension group. Both are convened once a week. All students are encouraged to submit individual projects, rather than collaborate to prepare group projects.

For the science fair preparation of the other students in the school, the teacher in charge of science was granted some 'release time' for one day when a reliever was placed in his classroom. During this day he spoke to every form two class, about the school science fair, including 'the 'scientific method, choosing a topic and methods of display. Although the projects are physically prepared at home, each class would spend about one and a half hours a week researching background information and writing draft copies of their experiments.

Towards the end of Term One a 'science fair parent night' is held at the school. This night was established four years ago to provide support to parents and children who may have been encountering difficulty or were apprehensive about creating a science fair exhibit. Children are encouraged to attend with their parent/ guardian. Approximately 200 people attended the 1995 science fair parent night where they received a sheet entitled 'How to Do a Science Fair Project' (See Appendix One).

During the evening it was emphasised that the project should be the child's work. Choosing a topic was discussed followed by details about use of scientific method stating " if you are a serious competitor 'the' scientific method is a must on your project" An example of scientific method was given using magnets as the focus of experimentation and was continued with a demonstration of electric motors and solenoids. Available school support, for example, of supplying science boards (upon which the display is mounted) for either $16.00 or $18.00, was explained. The Principal spoke to conclude the evening, reinforcing to the parents the active role of the school in this project. This could have been a strategy to mitigate the criticism that has been voiced in the past by parents who feel the school 'off loads' the science fair onto them with insufficient school backup.

"...one of the things that makes this such a good school is the support we offer ... this is the only school who runs one of these evenings....... " (Principal)

Five weeks prior to the science fair the regular classroom timetable for the computer room at Bayside school is put into abeyance and form two students have the major use of it to develop presentation material for their science fair projects. The computer room is also available for use before school from 7 am and until 5 pm at night. It is also open and available for use on Saturday mornings leading up to the science fair. Most children produce their final display with the help of a computer from home or school. If any projects arrive at school which are deemed to be 'substandard', teacher aides work with the child to make it of a presentable standard.

The science fair is held in the school hall which is open the Sunday afternoon before judging to allow projects to be brought to school carefully by parental cars, rather than on buses. The exhibits are then judged by teachers at the school and a number of science teachers from the local high school, using the criteria of the regional science fair. The hall is open during the week of the science fair during the day and also until 7 pm each night for parents and children to come and view the exhibits together. There is a timetable for teachers from Bayside school to provide supervision and ensure there is no tampering with projects. During the day, classes from within the school as well as classes from the surrounding primary schools visit the science fair.

There are four levels of certificate given for school science fair award winners. For each there is a different coloured certificate. Every project in which the judges perceive a 'good' degree of effort is eligible for a green 'Commendable Effort' certificate. Those in the top 50% of projects in their category are eligible for a blue "Award of Merit'. The top 20% of projects in their category receive a yellow 'Highly Commended'. The top sixteen projects receive an 'Award of Excellence', a red certificate. (Only sixteen are permitted entry to the regional science fair). The certificates are printed on good quality card and feature as their central motif, a row of test tubes, flasks and a bunsen burner (see Appendix One). At the conclusion of science fair week the winning exhibits in each section are carried down to the 'multi-purpose room' for safe keeping. Then the students may choose to fix up damaged parts or rework parts of their display. The teacher with responsibility for science spends time with these students, questioning them on key aspects of their projects. This aims to prepare them for the interviewing which is part of the judging process of the North Shore Science Fair.

Participation in the 1995 Bayside School Science Fair

The 1995 Bayside School Science Fair was held in the final week of June. The school hall was packed with 347 science fair projects with their attendant noises and smells. The overflow spilt out into the hall foyer.

A great deal of enthusiasm and care was evidenced by parents in the way that they were interacting with their child, their child's project and projects of others when helping to set them up. During the science fair week when the hall was open to the public, community interaction was particularly evident. During the day classes of primary school children visited to view the fair as did many elderly members of the community. After school, many parents visited with their children and were observed discussing projects with them. Secondary school students passing on their way home called into the hall and were overheard discussing the projects positively and reflecting on their days at Bayside school and the science fair projects they had completed. The number of exhibits in each category and presented by boys and girls varied widely. This is shown in Table 4.2 and 4.3.

Table 4.2

1995 Bayside School Science Fair exhibits

Category	Form 1		Form 2		All Students		Total
	Male	Female	Male	Female	Male	Female	
Plants	2	12	17	23	19	35	54
Animals	1	1	8	11	9	12	21
Human Biology	0	1	8	19	8	20	28
Environment	0	2	3	1	3	3	6
Con.Sci/Prod Test	5	1	36	37	41	38	79
Con.Sci/Foods	2	1	6	10	8	11	19
Chemistry	2	6	7	5	9	11	20
Electricity/tronics	2	1	26	5	28	6	34
Light/Energy	0	0	13	10	13	10	23
Engine/AppPhysic	3	0	25	10	28	10	38
Innovations	1	0	2	0	3	0	3
Geography/Erth Sci	0	0	14	8	14	8	22

The two categories which attracted the fewest exhibits in the Bayside Science Fair were Innovations and Inventions and Environment. The two areas which attracted the largest numbers of exhibits were Consumer Science -Product Testing (22% of the total exhibits) and Plants (15.6% of total exhibits).

Negligible differences existed between the numbers of boys and girls exhibiting projects in most categories. However, girls exhibited 64% of the Plant section and 71% of the Human Biology section. Boys exhibited 82% of the Electricity and Electronics projects, 74% of the Engineering and Applied Physics projects and 64% of the Geography and Earth Science projects. These areas of difference reflect the traditional male and female orientations within sciences.

The sixteen top projects were selected by a panel of judges comprised of teachers and management from Bayside school, the teacher with responsibility for science and science teaching staff from the local High School. These exhibits which win an 'Award of Excellence' at the Bayside Science Fair are exhibited, after some 'reworking' and interview preparation at the regional science fair. The categories of the top sixteen projects submitted to the regional science fair and the gender and form level of their exhibitors are presented in Table 4.3. In addition, of those projects which were selected as the top sixteen, those which had been developed with the benefit of the science extension class are denoted.

Table 4.3

1995 Bayside Science Fair - the sixteen top projects.

Category	Form 1		Form 2		Projects developed in science extension	
	Male	Female	Male	Female	Form 1	Form 2
Plants				1		1
Animals				1		1
Human Biology				1		1
Environment			1			
Con.Sci/Prod Test				1		1
Con.Sci/Foods Tech			1			1
Chemistry	1	1				
Electricity/Electronics			2			2
Light/Energy				3		2
Engineering/App.Physic			2			1
Geography/Earth Sci				1		
TOTALS	1	1	6	8	0	10

It can be seen that the projects were not selected equally from each section. In examining the sixteen projects, there is an emphasis on physical sciences, with nine of the sixteen coming from that area. There are slightly more projects from girls than boys in this top sixteen. Girls do almost as well as boys in the physical science area and better in the other areas. As can be seen at the end of the table, ten out of the sixteen projects or 60% of the top projects had been developed through interaction with the form two science extension programme.

Participation in the 1995 North Shore Science Fair:

Fifteen science fair projects were presented from Bayside school at the regional science fair, as one student fell ill and was unable to attend the judging. Thirteen out of the fifteen projects presented from Bayside School received an award. It is interesting to note that all, except one, of the prize winners at the regional fair level, had worked with the teacher with responsibility for science, in the lead up to the Bayside Science Fair. It could be argued that these results show the benefit of individual assistance and his personal 'scaffolding' of the task.

Table 4.4 reports the success of Bayside exhibits, by category in the Regional science fair.

Table 4.4

Bayside Science Fair Projects at the regional Science Fair

Category	Entries in Regional Fair	First	Merit	Special Prizes
Plants	1*		1*	1*
Animals	1*	1*		
Human Biology	1*			
Consumer Science /Product Testing	1*	1*		
Consumer Science / Food Technology	1*		1*	
Chemistry	2**		2**	
Electricity / Electronics and Communication	2**	1*	1*	
Earth Science, Geography	1		1	
Light and Energy	3**	1*	1*	
Engineering and Applied Physics	2*		2*	
TOTALS	15	4	9	1

** science extension project or in science teacher's class.*

(ii) Science Badge Scheme

The New Zealand Science Teachers' Association operates a Science Badge Scheme for schools. This consists of a variety of topics, for example ornithology, marine biology, horticulture, home chemistry. For each topic there is a sheet of activities, with each activity being allotted a specific number of 'stars'* (See Appendix One). In order to earn the Science Badge, students must complete a total of 20 stars. Students choose their own sheet and complete the activities as a homework activity over several weeks. The work is marked by their classroom teacher who records notes about it to be included in reports to parents. If the student wishes to receive the actual metal badge and certificate, they take their badge work and $5.00 to a member of the science curriculum committee who then presents them with their badge. The teacher with responsibility for science is expected to assess three submissions of science badges, representative of a range of ability, from each class, each term in order to monitor the school's standard. As science badge sheets are set as homework, their completion depends to a greater or lesser degree, depending on the level of child's motivation, on parental support. Parental support can also be seen in the funding of the metal badge.

While the teachers reported some parental discontent with the science badge scheme, which was relayed during parent interviews, there is sufficient support for it to remain a tangible and viable component of the Bayside School science programme. Once the badge has been completed, the children wear the science badge on the sleeve of their sweatshirt. The badges are two centimetres round in diameter, made of metal and include the title of the badge, for example 'astronomy' and a symbol to represent that area of study. If the child has complied with the school scheme, they will be wearing five of these on their sleeve by the end of form two.

(iii) The New South Wales science competition

Bayside school also participates in the New South Wales science competition. This is an examination system established by The University of New South Wales. Classroom teachers 'invite' students of high ability to sit the test. Of those invited, students who are interested return a permission slip from their parent/ guardian together with $3.00. The test is comprised of multi choice items of a scientific nature. During the weeks leading up to the test, the entrants are given some practice on past test papers by a member of staff during class time and are offered advice on sitting multi choice papers. When the test is sat the answer sheets are sent away to be marked. Results are returned and give each entrant a percentile ranking compared with other children of the same age in New Zealand and Australia who sat the same test. In 1995 160 students at Bayside school chose to sit the test. From these 31 children gained distinction which means they achieved in the top 10% of New Zealand entrants. Thirty-nine gained a credit which is awarded to the next 20%. All other entrants earned certificates of participation.

(iv) The BP Problem Solving Challenge

The British Petroleum (BP) Corporation support this event which is held at various centres around New Zealand each year. Teams of four students from each school are given 'problem solving briefs', for example, constructing a shelter, and are given a limited supply of materials with which to achieve their objectives. This competition differs from the maths problem solving challenges as it involves hands-on materials and is more science-orientated in content, for example incorporating pulleys, levers and properties of various materials into designs. At the end of the given time the artifacts produced are judged on their utility and aesthetic attributes. Participants receive a free cloth sleeve badge from Bayside School to sew on their sweatshirts.

Upon receiving notification of the challenge from the BP Challenge organisers, classroom teachers were asked to choose practical, bright children who could work co-operatively and who were not in any other extension group, so as to provide equity of opportunity. The Bayside school workshop craft teacher was charged with the responsibility of taking a slightly larger group than was required and selecting those most suited to representing the school at this event. He spent approximately six hours in total selecting and training the team. Training and selection activities included building effective compression and tension systems to make tall structures or structures which would span as far as possible. These were constructed from string, sellotape and newspaper. The form one team from Bayside school came third out of twenty other intermediate schools in the region.

4.5 Summary

Through examining the resources and symbolic elements of the Bayside School culture, it could be argued that the school places emphasis on science. The designation of specific space for its teaching, funding for teacher release time to teach extension groups, many boxes of equipment, money spent on posters, science books for the school library and encouragement of the wearing of science symbols reflect this emphasis. However, the emphasis is skewed in a traditional and competitive direction.

The main themes which have emerged from examining how school science is delivered at Bayside are:

- provision of tangible support for teachers through the work of the teacher with responsibility for science;
- emphasis on the physical science area;
- the use of outside schemes, such as Science Fair and Science Badges;
- support for competition, selecting the most able children for extra help;
- a teacher-focus with little opportunity for children's investigations;
- wider community interaction, especially around the event of science fair;
- dependence on parents' academic and monetary resources to support science activities.

There is some disparity between what the national science curriculum requires and what is delivered in science at the study school. In its interpretation of the science curriculum and development of a scheme, Bayside school has imbued the scheme with its own ideas. Furthermore, in its operation of the scheme, in terms of support provided to teachers through prepared lessons, there are additional disparities between intended and implemented schemes. An espoused aim of the science curriculum and in the Bayside scheme was 'science for all'. However, it could be argued that Bayside is providing most support to its most able students to prepare them for competitions. In addition a programme, which relies on parents being able to support their children financially and academically assumes a wide range of resource that some, even in an high socio-economic area such as Bayside, may struggle to provide.

It has been argued that the science curriculum indicates an underpinning of contructivism. In its interpretation of the curriculum, Bayside's science scheme incorporates constructivist rhetoric, however, its inconsistent and confused use of terminology reflects an attempt to convert existing schemes of work to match the new curriculum, without changing the actual nature of the approach. Thus while the curriculum emphasises learning in relevant contexts, Bayside supports, for example, a form two unit focusing on the 'topic' of 'chemistry'. Similarly, while the curriculum stresses the importance of children investigating their own questions while studying a contextual strand, the support provided in prepared lessons at Bayside consists of step-by step instructions to be followed. Opportunities for students to investigate their own questions are left to discrete 'packages' of Science Badges and Science Fair.

In its general aims the science curriculum emphasises the constructed and tentative nature of science and its usefulness to society. These philosophical emphases are absent from the Bayside scheme. Present, however, are elements with a more traditional focus, such as the importance of well established classroom routines, goals for winning science fair competitions and written post-tests for assessment. This could reflect a traditional approach to teaching and a conservative community.

Chapter Five

Teachers' Perspectives on Science Teaching

This chapter details two areas of teacher perspectives in respect to science teaching at Bayside school. In the first section teachers' characteristics are described, in the second teachers' attitudes to science and its teaching will be discussed and in the third section, teachers' self-reflection on their science teaching practice will be outlined.

5.1 Teachers' Characteristics

The classroom teaching staff and management of Bayside school were invited to participate in a loosely structured interview. Nineteen people, 100% of the classroom teaching staff and management accepted the invitation. Interviews took approximately half an hour each and were audio taped and transcribed. The first part of that interview dealt with teacher characteristics and is reported here. The composition of the staff is outlined in Table 5.1.

Table 5.1

Staff composition at Bayside School

Staff	Male	Female	All
Management	2	1	3
Classroom teachers	4	13	17
Technicraft Teachers	3	3	6
Ancillary staff	2	3	5
All	**11**	**20**	**31**

The staff of Bayside school is comprised of a Principal, two Deputy Principals, and seventeen classroom teachers (including the researcher). The classroom teachers are thirteen females and four males. In addition there are six technicraft specialists teaching textiles, workshop craft, metal technology, foods, art and music, of whom three are male and three female. There are also three office staff who are female and two male caretakers.

5.1.1 Teaching experience

This section will outline the years of teaching experience and years of service at Bayside School held by the classroom teaching and management staff. (This data is not recorded from the researcher.)

(ii) Years of teaching experience

Teachers gave numbers of years teaching, but this should not be interpreted as indicative of age as many teachers have had breaks in service for travel and child rearing. In addition some teachers have trained in teaching later in life. The distribution in Table 5.2 shows a cluster of teachers with 11-15 years of service and a group of teachers with 26-35 years of service.

Table 5.2

Years of teaching experience

Numbers of years	(N)	%
0 - 2 (Registration)	3	16
3 - 5	1	5
6 - 10	3	16
11 - 15	6	31
16 - 20	2	11
21 - 25	0	0
26 - 30	2	11
31 - 35	2	11
All	**19**	**100**

(iii) Years at Bayside School

These data were collected through teacher interviews, towards the end of the first term, 1995. In this way the considerable group of new teachers to the school would have a chance to experience science in the school. Table 5.3 shows there is a group of slightly over half of the classroom teaching staff interviewed who have been at Bayside school for less than two years.

Table 5.3

Length of time teaching at Bayside School

Numbers of years	(N)	%
0 - 2 (Registration)	10	
3 - 5	5	
6 - 10	1	5
11 - 15	2	10
16 - 20		
21 - 25		
26 - 30		
31 - 35	1	5
All	**19**	**100**

5.1.2 Science experienced at school

For most classroom teachers and management staff, the highest level of science was form 6 biology, although it is also interesting to note that there were three teachers who took physics and/or chemistry at the upper secondary level. Some teachers took more than one subject. The data from one female teacher is missing as she could not remember science taken at school and data is not recorded from the researcher.

Table 5.4

Highest level of science studied at school

	Male	Female	All
5th Form Science		1	1
6th Form Biology	1	7	8
6th Form Chemistry and Biology		1	1
6th Form Chemistry and Physics	2		2
7th Form Biology	2	1	3
7th Form Chemistry and Biology		1	1
7th Form Chemistry and Physics		1	1
7th Form Physics		1	1
All	**6**	**12**	**18**

In addition, during the teacher interviews, there appeared a cluster of nine teachers who spoke of biology with extra enthusiasm, using phrases such as 'favourite topic', 'found bio really interesting', and 'enjoyed bio very much'. These 'enthusiasts' reported enjoying the practical activities associated with the subject such as field trips and dissections. Out of the other teachers only one said that he "couldn't be bothered" doing biology. In contrast, two teachers recollect a predominately text-book orientation to secondary school biology teaching.

Seven teachers stated their reasons for not choosing to take physics or chemistry although this question was not explicitly asked. Some responses focused on the mathematical and formula content of the subjects not being appealing. Others talked about lack of confidence and not perceiving any application or interest in the subject. The image of science as a difficult, masculine preserve was evident in two responses:

> " Physics was not taught at my school with any enthusiasm at all and it was very much regarded as something which the Boys High School had under control and the girls' school sort of tended to focus a bit more on biology ... there were one or two weird girls who did Physics, but not us 'real proper girls'". (t.4)

Then from a first year teacher:

> "There was an attitude in the school where I was at where Physics and Chemistry were for the top-notch kids. It was perceived as being a 'hard' part of science to do". (t.16)

The differentiation of subject choice on a hierarchical and gender basis was also evident in the Principal's comment of

> " I took Horticulture which was quite unfashionable for an academic girl in the early '50's"(t19).

However this 'pigeon-holing' of subject to person-type was not restricted to females. The teacher with responsibility for science also fell prey to stereotyping including gender stereotyping:

> "I was into technology myself as a child but at the same time I maintained a normal behaviour pattern for a boy, like I belonged to the First XV, I was in the tennis team, I did all those conventional things but there was another side of me that was more or less secret ... I sort of tinkered but I kept that quiet..." (t.6)

Science enthusiasts are often viewed as 'nerds'. Two people interviewed argued that they did not see themselves as these "science sort of people" and one of them viewed "science sort of people" as having a narrower subject base like the "accounting/ economics sort of people".

There was a cluster of about a third of the teachers who, when recollecting their own science education experiences, pointed to the teacher's role in making it enjoyable or not. One woman recollects her high school science teacher as:

> "a person who was a tremendous role model. He often had fourth form horticulture and Agriculture and fifth form biology in the room at the same time. He was a master planner and has all of us doing hands-on 'stuff', whether we were the horticulture group or whether we were the biology group and I think he inspired me to see lots more links than science being something you just did in the lab when you did your odd chemistry things...". (t.19)

In contrast, one teacher remembers:

> " I had very structured lessons with a woman who ... the HOD at the secondary school was somebody who we didn't particularly respect as a person and so, unfortunately, we didn't really respect her subject much either...". (t.4)

5.1.3 Preservice and inservice science

This section reports on science experienced at teachers' college and any science courses undertaken whilst employed as a teacher.

(i) Science experienced at teachers' college

It should be noted that many of the teachers trained under different systems and in a variety of countries. In addition, some teachers' training is not at the forefront of their memories. Therefore it was not feasible to list the training completed in terms of hours. Most, however, simply completed the compulsory course (which today is usually 50 hours or a part-time course distributed over half an academic year) and almost as many could not remember. See Table 5.5

Table 5.5

Science experienced by teachers at teachers' college

Science course(s) undertaken	Teachers (N)	%
Science was the 'major'	4	21
Compulsory course plus two optional	1	5
The compulsory course plus one optional	2	11
The compulsory course	6	32
Six weeks if we were lucky	1	5
Can't remember	5	26
All	**19**	**100**

Many of the teachers who could not remember commented that this could be a reflection on the quality of their course or an indication they were more interested in other aspects of their training.

(ii) Science courses completed since leaving teachers' college

Teachers were asked about any courses in science education that they have undertaken since leaving Teachers' College, during their entire professional career. While teachers have attended courses when directed by their school, such as courses held on teacher-only days and since 1994, courses held as part of the Ministry of Education teacher development curriculum contract initiatives, related to the implementation of the new science curriculum, few have opted to take extra training in science of their own volition. Of those who have, the Advanced Studies in Teaching Units or ASTU papers are an option taken by one through Teachers' College. At times courses have also been run by the Educational Advisory Service. See Table 5.6

Table 5.6

Science courses completed since leaving teachers' college

Science courses completed	(N)	%
Frequent course attendance	2	10
An ASTU paper	1	5
Curriculum Contract on new document	3	16
Teacher only days at school	7	37
None	6	32
All	19	100

5.2 Attitudes to Science Teaching and Science at Bayside School

Management and staff attitudes to science teaching and views of science in the school are described.

5.2.1 Non science-specialist staff attitudes to science teaching

The 18 management and classroom teaching staff, excluding the teacher with responsibility for science, were asked to describe their attitudes to science teaching.

They responded to the question in two ways. They plotted themselves on scale from one to ten. One indicated a negative attitude, five a neutral attitude and ten a very positive attitude. The spread of the self-reported attitude ratings above indicate a generally positive attitude to teaching science. There appear to be two main clusters. One cluster of seven teachers in the 'six to seven inclusive' range and a cluster of eight teachers in the 'eight and above' range, which could be interpreted as leaning more towards very positive than neutral. These results are displayed in Table 5.7.

Table 5.7

Self-reported attitudes to teaching science

Attitudes	**Teachers** (N)	%
1. Negative		
2.		
	1	5
3.		
4.		
5. Neutral	2	10
	2	10
6	3	15
7	2	10
8.	3	15
	3	15
9.	1	5
10. Positive	1	5
All	**18**	**100**

However, while this sets the scene, it tells the reader little of the thoughts, feelings, opinions and experiences which meld to form such attitudes to teaching science. The next section will discuss the factors affecting general attitude, positive or negative, to science teaching, which were expressed when the teachers were asked to describe their attitudes to teaching science.

(i) Regard for teacher with responsibility for science

Ten out of eighteen interviewees gave very positive unsolicited responses about the person in charge of science. (The teacher in charge of science did not comment on himself, therefore is not included in the eighteen interviewees). In most cases these were regardless of whether the individuals agreed with the style or approach in which he supports science in the laboratory. Teachers appeared able to view personality traits as separate from the products of the person's work. One response in particular encapsulated the possible ramifications of having a person in charge of science who was less motivated:

> "... because I know in some schools, science is a real ... poor relation to the other subjects because the teacher in charge of science just says " well the stuff is in the science room and this is what you are supposed to be doing this term ... and here's a few ideas" ... and in fact you never get the few ideas, you just got the topic ... and that was it ... and most teachers used to skip doing it ... can't be bothered ... and then in another school I went to, a box used to arrive in the classroom and thirty six children had to deal out of one box ... and so again the teacher thought " I can't be bothered with this ... I'll just hold this up and say : this is what .. this is this and this is this ... Now write it down" ... and no practical hands-on at all ... Bayside does very well I think ...". (t.10)

People's comments regarding the teacher in charge of science focused on his commitment , his approachability and his 'Monday Help Sessions'

> "people can go and see the science resource person at a certain time and you know that he's always going to be there so you can get help". (t.3)

(ii) Feelings about prepared lessons in the laboratory

The second major theme which emerged from the open question about attitudes to science teaching was the teachers' positive and negative feelings towards the prepared lessons provided in the science laboratory. It was interesting that although the question "How would you describe your attitudes to teaching science?" was presumed to be quite open and non-directive, most teachers referred to the prepared lessons in the science laboratory. Very few spoke of the lessons in other areas, such as the Living World, where, other than being given the objectives, they are left to devise their own units. This could be a reflection of the high usage of the prepared science lessons in the laboratory, as every teacher used them with their class.

Just under three quarters of those interviewed spoke on the positive aspects, including, the benefits of having the equipment set up, the advantages of the structure provided and from a few that freedom did exist within the unit to 'do your own thing'.

Having the equipment set up and ready in the laboratory together with the lesson sheets was spoken of as "the luxury of having the equipment set up for us" and "here you can just stroll in and everything is there for you because t.6. does that for you". In fact the verbs most often associated with this system of organisation were 'pedestrian' in nature, such as 'stroll' and 'walk' implying that the teacher did not have to rush to organise everything themselves. It was under someone else's control.

Most of the twelve responses referred to the benefits of the structure and support in terms of knowledge that these prepared lessons provide.

A typical example was:

"I think they make it easy for us if you are not strong on science, which is good, you know the fact is at the end of the year you can at least say you have taught this, this, and this, and you have been handed lessons for it and the material was set up for you and you have been handed pretests and post-tests or whatever ... and I think that is good. At least the individual teachers, as I say, who have no ability or little interest in it that area ... it is perhaps like me down at PE where it is great having the units because I really haven't got the know-how of all those skills in different sports." (t.5)

There appeared to be a continuum of reliance on the lessons ranging from

"..having a structure to work from, it's like a crutch and OK you know where we should go with it and we can follow it through" (t.5)

to ...

" what t6s' stuff has enabled me to do is to get a basis from which I can pull the threads from the curriculum really". (t.12)

For a first year teacher there is security in knowing

" that everyone is doing the same, it sort of helps me". (t.7)

One response regarding the benefits of structure focused on the dual benefits to both teacher and students:

"Yes I do like it because it is structured, you feel that the children are learning something and you can go out the door with ... today I learned A B C D that I didn't know' ... and it's instant gratification, the science, so I really enjoy doing that part of it with the children, it's not something that has to be proof read and worked on for another week and then handed in ... it's instant ... did you know?' and they didn't and they go out the door knowing something new that they didn't know." (t.10)

Finally, many teachers mentioned that they realised there was the freedom to 'do your own thing,' however, for all, lack of time and/or background knowledge had militated against this. These more major themes will be elaborated on after an examination of teachers perceptions of the negative aspects of the prepared laboratory lessons provided.

Just over half of the teachers had negative comments to make regarding the prepared laboratory lessons. It should be noted, however, that in almost every case, teachers could argue for both the positive and not so positive aspects as they saw them.

The language used by the teachers and management staff, in the interview discourse, to describe the teachers' view of the negative aspects of the prepared science lessons can be grouped. The management of science was described as convenient and pragmatic. The science teaching approach was described as set, formalised, traditional, science of a certain type, generic, paint-by-numbers, recipe book approach. The scope of the science lessons was described as narrow, staid, and restrictive. However, the language associated with the positive aspects of the prepared laboratory lessons expressed should also be acknowledged to present a balanced picture. Words such as 'ready-to-go', 'quick and easy', 'crutch' ,'hands-on', 'uniform standard of delivery', and 'proper' were also used, with 'structure' being mentioned many times.

In addition to the sentiments expressed through the language used, there emerged four areas of concern with regard to the prepared lessons. There was concern expressed over lack of everyday context in the lessons, their teacher-directed nature, an attendant danger perceived of teachers being underprepared, and that most felt compelled to adhere to the format as outlined.

A third of the teachers who made comment spoke of concern over what they perceived as a lack of everyday context in the prepared lessons. One teacher suggested making it more fun

" and more relevant, rather than kind of working from those worksheets and doing the experiments and it goes totally over the kids' heads because they can't connect it to anything ... you see doing lime water and those kinds of things ... I don't think is getting to the children ... they do the tasks .. but unless they are very bright they don't make the connections ... that's my view anyway." (t.2)

A similar sized group talked of the teacher-directed nature of the prepared lessons:

".. although the activities are good, it doesn't really take much thinking to work them through ... they could be a bit more ... problem solving ... I mean you could give them the outline and say ' how can you do this, using what instruments or what activity ... what media can we use to get it...' rather than giving it straight to them and then just doing it ..." (t.7)

Identified by half of the teachers who made negative comments was the danger of teachers 'walking' into the science laboratory having insufficiently prepared, personally, for the 'prepare d' lessons. This phenomenon will be further discussed later under the 'preparation' theme, however this quote gives an insight:

"..it is a great help having the science lab all ready and set up ... in a certain way ... on the other side again ... it is set up and sometimes you walk in and you think to yourself " what am I going to do with all of these things?" because I am not always there for W ... to go to his meetings because I am on lunch duty at that time so I miss out on his meetings sometimes ... so I can walk in there sometimes and "what has he put out there for me?" It happened to me twice and after that I said 'no more' and made sure that I knew what was going on there". (t.13)

Finally there was perceived by two teachers lack of flexibility, since the equipment was organised sequentially by week and 'topics' or 'Worlds' were set for each term.

The positive and negative comments and language used referring to the prepared laboratory lessons, could be aligned to an analogy of fast food such as McDonald's. Both are standardised, hands-on, quick and easy, ready to go, of a certain type and narrow. While both perhaps as 'convenience foods' contain certain essential elements, it could be argued that they are not a complete diet on their own.

In contrast to some teachers' adherence to the laboratory lessons, one teacher spoke of delivering her science in a slightly different manner. In this excerpt from her interview transcript, she gives her rationale for so doing and points to some of the implications for her students and herself.

" What I like to do is to say to the kids ... well what are you interested in ... or say you know ... hey listen! ... what about light ... what do you think light is? ... and then talk about it and then to say ... look ...OK if you are going to talk about the way light behaves ... if I put these prisms down in front of you, they are all different shapes, what would you think might happen if you put a beam of light through them ... and so on ... you see we did a lesson like that, well for about three or four days after that the kids couldn't leave their plastic rulers alone, and they were getting bottles and wanting to look through those, which I was really pleased to see ... and that's what I would hope would happen is that kids develop their own permission to enquire and their own process for following an enquiry through ... but I'm not sure as it stands that the programme does that and I feel as though I am bit of a renegade or a bit subversive (I like to keep that a bit quiet!) and that in the end I don't end up with a particularly smart looking skills book either." (t.4)

Another teacher also spoke of the need for more child-directed enquiry of the sort she has seen through her involvement with the new maths curriculum. She saw little opportunity for students' own investigations in the prepared lessons. She also flags the crucial issues to be tackled if teachers are to shift from heavy dependence on the prepared laboratory lessons.

"..having been on the maths curriculum ... where the whole turn was away from teacher directed and into pupil investigation ... not actually giving them all the information first but saying ' this is the equipment ... go away ... this is your question ... see what you can come up with' and let them question and find out those things as they needed to rather than giving it to them prior. Which I think doesn't occur in some of the science lessons, but again I know I could do that but it all goes back to me having the confidence and background knowledge ... because then I could ... I wouldn't feel it necessary to stick solely to prepared lessons ... I would feel more confident to work from the curriculum itself and do it that way." (t.8)

(iii) Importance of background knowledge

Another theme which emerged when the teachers were asked to describe their attitudes to teaching science, was the importance of background knowledge to having confidence in the teaching of this subject. Connected to this was the relationship some teachers perceived between their own confidence and the ability to enthuse the students in science.

A fifth of those interviewed discussed their enjoyment of teaching the 'Living World' section of the curriculum, as it fitted with their background knowledge bank, gleaned from secondary science. The following quote demonstrates a contrast in a second year teacher's attitudes to teaching areas she has background in compared with an area with which she was unfamiliar:

"...so I'm far happier about it this year than I was last year. But I think that's also because I am doing something I know about because we did do, I mean I'm picking up the evolution with my social- studies but we also did lots of adaptation stuff in Biology in the sixth and seventh form, so it's something I know about". (t.3)

She goes on to contrast this with teaching a unit on electricity last year:

"I can't say that I taught it at all. I can say that I took the kids to the science room and they completed the tasks but that had not very much to do with me. I had a boy from Room 13 who did more of the teaching than I did. He was helping out because I was not confident with the topic, although I knew what was going on and I knew what the kids were doing, but I don't know if I'd do it again this year, I think I'd see if I could find an alternative". (t.3)

One of the deputy principals also articulated a knowledge related concern. He discussed the subtle interplay between not only knowledge of content but also knowledge of process skills and the relationship between these two elements:

"... I never really got into the LISP (Learning in Science Project) approach really ... I never really felt confident enough um ... you are really working with the children much more and I feel as though that process is very sound but you've got to be very knowledgeable yourself and very confident that you can take it here, there and everywhere ... I would be quite happy doing that in a social studies type context or a sport/PE because I've got a good resource bank in those areas ... but when you have prepared a study on water science or what have you and you've just grasped all this stuff and for the first time formally thought it through ... you can't be that divergent...." (t.18)

Another fifth of the teachers felt they would have more confidence if they knew more. One of them commented

"...it's very easy when you are scientifically minded ... and I'm not saying that I'm not scientifically minded but I think it is a lack in my background that I have to, that I feel a bit nervous about presenting ... asking questions from the children, getting responses from them, um ... but I would like to learn certainly ... but I don't feel confident in it because I feel that my training is inadequate in terms of it". (t.14)

In contrast to this are three teachers who don't feel lack of background knowledge is a problem for a number of reasons. A first year teacher felt that in spite of a weak background in science, the hands-on teaching she received recently at Teachers College helped her confidence. The person with the least science background on the teaching staff gave one of the highest self-reported attitude ratings to the subject and spoke very highly of the organised laboratory lessons. It is possible that these boost her confidence. The third teacher expressed no concern with lack of background knowledge as she is more process orientated and is willing to have a go at anything.

Some teachers indicated a relationship between their background knowledge and enthusiasm and the enthusiasm of the students. One teacher indicated

"It wasn't a subject I would avoid because the kids were always so positive" (t.14) indicating some flow of feedback or influence from the children back to the teacher.

About a fifth of those interviewed identified the importance of background knowledge to the teacher being enthusiastic and then evoking response from their students. At the classroom level, one reluctant science teacher provided an interesting comparison with a subject she does feel enthusiastic about:

" You see for instance Social Studies ... I love ... I can't wait to get into it each day ... and particularly when I think I'm so keen and motivated ... for instance we are looking at 'living in a former colony' and we've looked at man's exploration of the earth and why did he explore and where did he go ... and I find it so interesting and I can't wait to ge t into it and my enthusiasm rubs off on the kids and so the kids are starting to question: 'well if this happened then what about such and such or did this occur over here as well?' and I get a real buzz out of it ... and by the end of the lesson I'm thinking 'wow' they are really interested in what we are doing. I don't feel that with science because I don't have the background knowledge and I don't have the enthusiasm for it so therefore they're not picking it up either". (t.8)

While the term 'background knowledge' almost implies a static parcel of knowledge acquired while at secondary school and teachers' college, the next emergent theme under discussion indicates more potential pro-activity on the teachers' part.

(iv) Importance of preparation and responsibility

Although teachers were not asked to comment specifically on how they prepared for lessons, many mentioned this in relation to other matters, such as lack of background knowledge. From the comments made, it became evident that there could be a possible continuum of teachers who take less responsibility for their preparation following through to teachers who reported completing background reading. It will not be assumed, however, if the teacher did not mention any aspect of preparation, that they do none.

Earlier, there was a quote from a teacher who had gone into the science laboratory twice without preparation and threatened never to do it again. Two teachers report having cancelled lessons in the lab. "because I haven't had a chance to go and talk to W. or somebody about what I have to do..." A second year teacher reflects back to her first year and noted "I sort of went in and thought 'well this is all planned so I don't have to do anything'. I worried about other things rather than worrying about science". A first year teacher this year states that his knowledge "will come with time".

Further along the preparation continuum the two Deputy Principals remembered enjoying preparatory work for lessons. One discussed the

"personal satisfaction of taking some information and then trying to convert it into a digestible form for kids. It helped me understand it a lot better and I felt that a lot of things were really quite exciting". (t.18)

The other found preparing for biological topics boring because he had that knowledge but he learnt from his preparation and planning and

" anything to do with the physics side or chemistry, to the extent that you do it in a primary school, I found very interesting because it was fresh to me". (t.17)

Four other teachers also spoke about doing 'extra' background reading and preparation. The following two excerpts from interviews point to the personal responsibility taken by these teachers for their own background knowledge, the benefits of this in their teaching but also the battle with lack of time for this preparation:

" But you still need, for something as specialised as science, you need a strong background knowledge so that if questions do come up you can answer them and also to stimulate responses. I don't feel that I can get the best out of the kids because I am lacking in certain areas of knowledge. We are doing this Radiant Energy and it's really very nice and the one very successful lesson I had, I did major reading and books out of the library and stuff like that ... well it paid off ... but I'm battling a bit from the time point of view ..." (t.14)

She continues talking about her background reading:

" and I got so interested ... and I was able to communicate it to the kids and they were ... I could see ... then as soon as I falter, then you can see straight away the response from them and that is where you get the discipline problems and all that sort of thing...." (t.14)

Another teacher discussed concerns about her lack of background knowledge adding

" there is nothing anyone else can do about that ...I just have to do my own reading and make sure I have plenty of information before I get on ... which I have done ... you know ... for the most part ... if I don't I do what I did yesterday and cancelled ... I actually came into school at half past seven ... and Mr Mc. sidelined me and we ended talking about camp and various behaviour problems with some of my students and meanwhile the minutes are ticking away and I am thinking 'Oh No!'. So my hours preparation before hand dwindled to nothing really ...". (t.12)

(v) Pressure of time

In all, about a third of those interviewed spoke of the difficulties in finding time to either do background preparation or devise their own science units in areas where they would be otherwise provided or devise new innovative units where they would have possibly 'recycled' old ones. In contrast, another three teachers felt that there should be more time for science teaching, one arguing she felt there was not an equal time footing with Maths and English.

One teacher, who appears motivated to plan exciting science units shared her thoughts:

" It's interesting that even after eight years of teaching, admittedly only four years at intermediate and first year in Form Two, I'm suddenly realising that I can't say 'it's not my forte' and not do anything about it ... that no matter what school I was in, it's really up to me to broaden my horizons a bit ... however, there is only 24 hours in the day ... That Teacher Only Day in science was brilliant ... Julie and Sarah and I had looked at a whole integrated unit which I thought was going to be really exciting on fishing, and it was going to bring in everything and look at preservation methods of fish ... how different cultures fished and so on ... and it would have been neat to have more time to finish planning it because we never ... the life of the school was so busy that we never got back to finish planning it ... and so it was never done...". (t.8)

(vi) Importance of integration

Four teacher perceived a need for more integration of science. Two wished to deliver it in a primary school type manner, by integrating it with other subject areas such as maths and language. In this way, they argued, it would not be as isolated and unconnected to other areas as it is perceived to be now. Another teacher also spoke of the need not to

"divorce ourselves from our primary roots and put our foot too firmly in the secondary camp of having science as a specialist subject per se" (t.17).

He saw a place for more classroom based science that didn't :

"so much carry the tag of science as solving problems or doing investigations". (t.17)

Finally, integration was seen by one teacher as a way of solving the 'lack of real contexts' problems in the prepared laboratory lessons:

" when we are looking at chromatography ... if teachers can integrate that with their 'law and order' ... as far as finger printing and those sorts of things ... that is where I would like to see it go." (t.18)

(vii) Perceptions of the nature of science and its teaching

In addition to the main themes overtly expressed by the teachers and management staff interviewed, during a number of these discussions it became clear that staff members held differing views of science and science education pedagogy. Of those interviewed eight used terms such as 'the scientific method', 'a proper science programme' and complained that children are not 'thinking like scientists'. This points to a more traditional perception of the concept of science, embracing positivist concepts of science being a fixed body of knowledge and uniform in its procedures.

If a teacher adopts positivist beliefs, possible implication s for science teaching practice could be the 'transmission mode' where the student is viewed as an empty vessel into which knowledge is poured. The teacher holds the dominant role and there is little interactive 'sense making' done by the student. However if the teacher views science as an evolving body of knowledge, where the subjectivity of the observer is acknowledged, then, it could be argued, they would be more likely to adopt a pedagogy which puts the child at the centre 'making sense' of their world.

However, the interviews also showed a small degree of selectivity in the adoption of the various tenets of positivist science thinking. Some teachers appeared to subscribe both to science as a fixed body of knowledge and a step by step process almost unconsciously. Perhaps this would be more likely to result in a teacher-centred pedagogy. One person seemed able to refute one tenet and adopt another, justifying it because, in her view, it improved the quality of the teaching programme. As the Principal, her views of the nature of science and its teaching, could have wide spread implications through policy making in the school. While she acknowledges the tentative nature of science saying

"... the whole thing about science is that the evidence is never in and that you test something and you may get an unexpected answer and that is in fact how knowledge grows ..."

she also used the phrase 'scientific method' and endorses a uniform step by step, hypothesis, observation, data collection and conclusion approach to teaching investigations in science. However, she justifies it on two fronts. The first that its adoption throughout the school improved the quality of the teaching as she saw it:

"... I think that in my time here that the science as I observed it ... it may not be how those who delivered it saw it ... but what I observed was delivering kids a package of knowledge and I think helped make a shift to the actual: ask a question, form a hypothesis kind of approach to going through science really ... I think that is to the benefit of the school really ..."

The second advantage of the adoption of a uniform approach to investigations in science was that it provided a firm structure and support for children doing independent projects such as the science fair.

"I think that myself and some of the staff who came aboard with me have had more experience at ensuring that that enquiry method was what was followed, as opposed to telling kids that they were to do a project and sending them off and they produced a science fair at home, by whatever means they could, that didn't follow the format. We have always had enough good kids through this school long before my time that they ... a certain number of them did it anyway ... but I think that the school has moved as a whole to that being a general part of our programme. And I believe that it has actually lifted the understanding of several areas of science and the understanding of what science is about ..."

So, it appears that some of the tenets of positivist thinking in science can be consciously adopted alongside postmodern views, and justified for reasons of perceived improvements in teaching and pragmatic reasons.

A small group of teachers made the observation that children they had encountered did not think like scientists and did not know how to carry out a scientific investigation. One expected that "they should have all that stuff at their finger tips" while another observed that when requested to write a 'scientific report' the children tended towards a creative writing style. A further teacher had observed a similar lack of skill, but was attempting to remedy it :

"...but it does take a lot of direction at this stage at the beginning of form one ... I found with my Flight unit ... I would say a third of my children were able to conduct an experiment and carry it out and handle the information and draw a conclusion ... a third out of 36 children is not very high ... the rest of them needed constant direction on where they were going ... the ideal at the end of the year is that I will be able to set them objectives ... it takes a lot to get to that level." (t.1)

There appears to be a contrast between some teachers who expect the children to already have the science-based skills and those who recognise it as part of their job to teach those skills.

(ix) Anxiety about measurable outcomes

A small group of teachers expressed concern over 'administrative' matters. They questioned the strong emphasis placed on measurable outcomes and what one termed as ' audit trailing'. In this excerpt from her interview transcript one of these teachers describes why she has difficulty with this thrust:

"...I have a reservation about the direction that a lot of subjects are going at the moment where I feel uncomfortable about the amount of value that is put on measurable objectives and measurable outcomes and I see that that kind of thinking is certainly accommodated fairly substantially at this school and ... I have some difficulty with that ... just simply because I think what actually happens in a science lesson or any lesson ... is not appropriately accounted for by a mark ... like I think if I'm wanting to just enthuse kids or just imbue them with some kind of open minded attitude, which is one of the stated objectives of the curriculum, I don't see that being consistent with then putting down a mark of eight out of ten in terms of performance on a particular skill in bending light ... and I don't see anywhere that that is really being accounted for ... although it is ones of the stated objectives." (t.4)

5.2.2 Attitudes to science teaching of teacher with responsibility for science

Because of his influence on science teaching in the school, it is important to elucidate the thoughts of the teacher with responsibility for science independent of the group. He presented a positive attitude to science teaching, particularly to science as a positivist pursuit and to science teaching which develops children's enthusiasm. Four themes were apparent when analysing the transcript of his interview. He emphasised the importance of content knowledge in and enthusiasm for science. He justified a formal approach to science instruction, elaborated on how science had bolstered Bayside's image in the community and explained his philosophical differences with the management team and the new science curriculum.

The teacher with responsibility for science was enthusiastic about his subject and believed there was a relationship between the enthusiasm of the teacher and that of the child. He also believed that a good knowledge base in the subject is essential. He described his 'formula' for making science a powerful force in the school, one which he believes peaked with the previous principal between 1987-1989.

"So if you can have someone who has a very good knowledge base and you have someone who is hell of enthusiastic about the subject, starts to get some feedback from kids because that enthusiasm and that gets like a snowball running down a hill, and then you get even luckier that that person has reasonable organisational skills ... and can get the thing organised and running and starts then to get everyone roped into it ... then you'll have a very powerful result, and that's what I think happened ... and that's what really happened about 1987-1989 and then it started to go down..." (t.6)

He also commented that 'real gear' and a room to teach science in is essential. This emphasis on traditional equipment and surroundings is also mirrored in his emphasis on 'the scientific method'. He recounted an occasion when the Secretary for Education came to visit the Bayside School science fair:

"...now I can remember when the lady from Wellington came ... the very top lady in education came ... Maris O'Rourke ... she came ... I actually did engineer this to a point that I actually chose about 35 kids who had the scientific method really well in their heads ... and they were standing by 35 projects and as she took her team of people around she tested for the presence of the scientific method ... I knew she would ... and I got her completely because it was perfect, ...every single one of them had it ..." (t6)

Consistent with this traditional approach are the prepared lessons in the science room. He argued that while these were not 'theoretically perfect education', they were manageable for teachers with little science content knowledge and large classes.

"And if you go and do group work, you have to have a thorough sequential ordering of the subject in your own head. How that is beyond 90% of people in primary teaching and that is where it will fall on its face ... so if you can get a teacher to walk into a room with some equipment and let the kids do an activity and if the whole class does the one activity and then you extend it by discussion or perhaps a demonstration at the end, and a few kids do some individual work at home ... that's not a bad effort. It might be all you can hope to achieve and its not theoretically perfect education, but it's a result that is positive." (t6)

The teacher with responsibility for science was cognizant of the attention attracted to the school as a result of science fair successes. In return, the school was generous with the science budget compared to other curriculum areas. He felt supported in this regard, disagreed with making science fair and science badges compulsory and setting targets of specific numbers of science fair prizes to win. These policies, he argued were written by the management team. He also disagreed with the way that the management were enforcing the new science curriculum with regard to assessing the new achievement objectives. He believed that the new curriculum was doomed to failure and called assessing the achievement objectives 'audit trailing' which he posited was at odds with developing enthusiasm in children for the subject.

5.2.3 Views of science at Bayside School

In this section all 19 management and classroom teaching staff were asked to comment on values underpinning science delivery in the school as well as commenting on the science fair and science badge schemes.

(i) Science fairs

Only nine classroom teachers felt able to comment on the science fair as some have only taught form one and have little to do with the school science fair. Others have only been in the school a term, therefore and have not yet experienced a science fair at Bayside school. Two teachers in this position made comment using their science fair experiences as teachers in other schools or as parents., and these comments will be identified as such. The comments made by management staff will be summarised separately at the end.

Over half of the teachers expressed concern over the expectation of parental involvement in the science fair. All five questioned the amount of parental input into the projects with one reporting the very negative parental feedback of:

"Science fair... very negative comments every year from the parents ... we all know that the winning ones are done by the parents ... why can't you accept an honest Form Two effort' that was one direct comment last year". (t.10)

However a teacher who had recently moved from another school had similar misgivings over how hard parents had worked on the projects at that school too. Of these five teachers, who questioned the amount of parental input, two raised questions over equity issues regarding access to motivated parents, access to computers at home and access to money for presentation boards and materials. It was felt that some children were being disadvantaged by lack of access to these things, but one of the teachers did acknowledge that the school does 'pick up kids' with potential and ensures that no one is embarrassed by their effort in the hall.

Closely aligned with the issues of parental involvement and equity is that of competitiveness. A third of the teachers used that word when referring to the science fair. In one case competitiveness among the parents was referred to, while the competitiveness of the school versus other schools was the focus of other comments. Two teachers out of the nine questioned the wisdom of making science fair compulsory for all form two children. It was perceived that the average and above average children could cope with it and in some cases excel but the below average children found it a struggle. To alleviate that problem one teacher was having her less able student complete the science fair project at school, rather than as a predominately home based activity. The same teachers also commented on how enthusiastic the children were once they saw all the projects displayed in the hall.

The three members of the management were very positive regarding the science fair. They viewed it as a valuable learning activity and were active in supporting it amongst the students and staff. As management, it also became necessary to defend the science fair to the community too:

"Traditionally every year we get people grumbling and groaning about the cost of the boards and the amount of time that the children are spending on it and that the parents are spending on it, and is it worth it ... and its usually the first deputy principal or Principal or myself who field the calls and again we defend the decision to take part in what we consider to be a worthwhile thing". DP2

(ii) Science badges

In answering this question classroom teaching staff commented from their experience in the classroom, the management's comments were directed more at the policy of and reasons for the scheme's implementation and will be summarised separately.

Ten of the sixteen classroom teaching staff interviewed were very positive about the science badge scheme, describing it as 'really neat', 'very good' and 'excellent'. Three teachers were more reserved describing it as 'good'. Another three teachers were negative regarding the scheme declaring it 'onerous and irksome' and 'a chore'. Therefore eighty percent of classroom teachers considered the science badge scheme favourably or better. There were three main aspects which influenced teachers positively towards science badges. They perceived the scheme enabled students to choose an area they were interested into investigate, with the potential later to look at a range of topics, if a number of badges were completed. The teachers perceived the research, investigative and experimental skills gained to be beneficial. They also thought the independence in work habits developed was valuable.

However, in almost every case, even when teachers were very positive, they voiced concerns related to the science badge scheme and how the school runs it. The concerns over the compulsory nature of the badges, parental involvement, the need to monitor the badges, and what the children gain from completing them, will be discussed in order of frequency.

A little under half of the teachers had concerns over the school's current policy of making the science badges compulsory for everyone. There was a feeling that the more able children were well equipped for the task but that the less able were poorly motivated towards the scheme and required much assistance:

" there are some kids who are really, really keen to do it and that's brilliant and to me exactly who it is for ... and then there are other kids for whom it's really just not appropriate and it's hard work to get them to go through it ... it's hard to get every child to jump through the same sort of hoops..." (t.4)

Perhaps related to the above issue, a similar sized group of teachers commented in varying ways about parental involvement in the scheme and parental attitude towards it. Two teachers report having negative feedback from parents about the scheme . Another four argue that it takes a great deal of parental time. Two of these said there is too much reliance on parents for the completion of the badge.

For a quality 'product' one teacher considered

" it takes a lot of input from an adult, whether it is the person in charge of science or their teacher or their parent ... for the kids to make the connections, they are not just copying the stuff, they are doing things ... they understand and can make connections too..." (t.2)

Just under a third of teachers spoke strongly of the need to monitor the science badge scheme, as it is run as a homework time activities, and to check that sufficient progress has been completed in a week, for example. This was seen by some as a way of helping children with their time management, but by others as unhelpful in this regard. One teacher argued vehemently that science badges should not be left purely as a homework activity but the skills inherent in the activities should be taught in class first, before the skill is practised, as homework, in the science badge. There were questions raised by a quarter of the teachers as to how many actual science skills compared to book research skills the children gleaned from the badge programme. There was a feeling that the scientific methodology content could be increased even further than it had been. However two teachers commended the scheme for giving the children a broad overview or taste of a wide variety of fields of scientific endeavour.

Three teachers questioned the regimented nature of making three science badges compulsory for form one students and suggested making the compulsory number less. Finally, three teachers commented on the positive response from the children once they had achieved their science badges.

The three members of the management team were very positive towards the science badge scheme, with the proviso that students were adequately monitored and not left entirely to their own devices. During the interview with the Principal it emerged that the school had rewritten some of the science badge task sheets with the aim of raising the level of scientific activity:

"We have modified the sheets ... and made sure that each activity has an applied science component, for example: collect six shells would not do for me because it just says collect six shells and you got six shells bunged in a plastic bag and pushed at you. I believe that as a scientist as soon as you make a collection you need to classify it and label it ... and whether you label it by its scientific name or whether you label it by white shells or yellow shells ... but we have tried to do that on all the sheets ... and I'm hoping I can talk the Science Teachers Association into doing that. Now, they would suggest that our school operates at a higher level and that they are probably inappropriate for a lot of places." Principal.

The system of ordering and receiving badges from — the New Zealand Science

Teachers' Association was also "very convoluted" so:

" I took it upon myself to make contact with the group that were running it and suggested that there were more efficient ways of doing it and after a bit of initial resistance they became quite interested in some of the things I had to say. I also set out to get them some substantive sponsorship which was $7,000.00 last year and $5,000.00 this year to let them get onto a viable footing and keep it going." Principal.

This scheme is valued by the management and most classroom teachers describe it positively, although some teachers question the policy of making the badges compulsory and have other misgivings.

(iii) Values underpinning science delivery at Bayside

Management and classroom teachers were asked to comment on the values they perceived as underpinning science delivery at Bayside school. Of the nineteen staff interviewed, three people felt that they had not been teaching long enough at the school to comment. Of the sixteen who felt able to comment, over half observed that 'formal' science, with prepared, teacher directed lessons and emphasis on the scientific method was a tangible value.

"I think it has been done on a more traditional basis, you know its always been done and that's the way its done. I think it should be done with more flair and a new approach to it ... like not having those worksheets ... (t.2)

Another group felt that the way the prepared lessons emphasised hands-on activities was also part of the foundation of school culture:

"I think ... very much hands-on , experimental, teaching to criteria that are set." (t.1)

A quarter of those who offered responses stated that the high level of school involvement with science fair and science badge schemes and the provision of a science room denoted a value of competition:

"I would question a bit about whether we are providing science education to the masses as opposed to perhaps attempting to look at, not so much the elite, but our top kids, they get very well catered for through science fair, New South Wales competition, through science extension groups ... and that's laudable and that's fine and the school can be proud of its record and all the rest of it, but I just wonder what the general level of science would be." (t.17)

It was also felt that strong leadership and ownership of science was a value - underpinning science delivery at Bayside. One of the deputy principals summarised many teachers' feelings when he said :

"Perhaps one of the values in science in this school is that teachers see it as being owned by a particular person, they personalise it to a person and that is a real strength in that they know they can always go to that person ... and get support or advice ... very accepting ... (t6) is very willing to help and pass on the knowledge and he is very keen for people to be successful in science ... because he enjoys science and wants other people to have a good lesson in the lab." (t.18)

Coincidentally, the teacher with responsibility for science corroborated these perceptions by including in his interview the unprovoked statement :

"...like when you walk past the science room and it's running rather rough and then you say "how did it go?" and they (the teacher) go "Oh you know" ... well then you've got to try really hard next time they come ... to teach them what to do ... and you know you have to ... because if they don't manage it then it is really your fault, my fault , not theirs ... and that is the hard bit ... that is where the load comes." (t.6)

The high level of community support was also commented upon as an important value:

'We are lucky in that the children we have here in this socioeconomic area ... they have got parents who are encouraging and are probably working in industry and professions and they have a lot of feedback from the parents at home who can help them with ideas..." (t.7)

5.2.4 Management perceptions of support for school science

In addition to the questions already reported on, the three management staff were asked how they perceived they supported the teaching of science in the school. The Principal's response has already been reported in terms of her activities at an National level to have the science badge scheme run more professionally. Her views of scientific method and the leadership role she has taken in introducing her concept of this into the school have already been discussed. The two Deputy Principals perceive their support in terms of checking that teachers have taught what they were supposed to, and this is done through regular planning checks. The Deputy Principal with responsibility for curriculum also perceives that he provides support by enforcing accountability systems, ensuring the teacher with responsibility for science is performing this function. He explains his role in supporting science delivery:

"The requirements we put on classroom teachers to follow the scheme and to actually give an account of the science you have done in each term and the a reason you haven't done it ... that is a way that I, as the curriculum manager am supporting the Teacher with Responsibility for Science. Also in supporting science I am also requiring of the Teacher with Responsibility for Science ... in that what we put in the scheme ... I met with him last week and went through all the jobs that need to be done to ensure ... that we actually get those done". Deputy Principal 1.

Support from the management, for science teaching, it appears comes in the form of leadership with respect to curriculum interpretation and systems put in place to ensure accountability and smooth functioning.

5.2.5 Technicraft teachers' perceptions of relationship with science

The four technicraft teachers were interviewed with regard to how they saw science relating to their subject areas. Three main ways emerged, of how science relates to the technicraft area; with regard to problem solving processes, science related to content being taught and helping students with science fair projects.

(i) Science related to problem solving

Only the workshop craft teacher commented that he perceived a relationship between problem solving processes inherent in science and problem solving processes he taught in the workshop. This was the closest link he could see between the two areas, where he could perceive students receiving reinforcing process skills from both science and workshop craft.

(ii) Science related to content being taught in technicraft

The technicraft teachers all included some discussion of science content in their lessons when making articles out of materials, or trying the achieve special effects. The workshop craft teacher discussed talking about heating of acrylics with his classes, and what happens when they are over heated, in terms of spoiling the desired decorative effect on an article. He also discusses summer and winter growth rings on timber during a project where they have to identify the soft wood to burn it out to make a decorative effect. He included copper-work as an example of how science is applied throughout his subject without conducting specific lessons on it:

"... the kids apply it ... it is an applied science in a sense ... they are the ones who get their copper clean, why do they get it clean? Well, they need to remove all the old tarnish. Why?, because the oxide needs to affect the actual pure metal, they know that, so they clean it, they put it in the solution ... it goes the colours they want and now they have to wash it off with water to stop the reaction still carrying on ... so it is quite a science involvement." Workshop craft Teacher.

During his lessons, the metal technology teacher talks about the chemicals involved in soldering and the composition of metals as well as the effects of sulphur on copper. The textiles teacher perceived a relationship between her subject and science as far as testing various materials. She commented that children require a threshold of ability to carry out that sort of work and evaluate it. Also, the number of technicraft lessons did not allow for such investigation as well as learning 'the basics'. The food technology teacher relates science in her classes with the use of raising agents and chemical reactions involved in the cooking process.

(iii) Involvement with science fair projects

All of the technicraft teachers have had involvement in helping students with science fair projects. Both the workshop craft and metal technology teachers commented though, that often the students request help with the construction of items without asking them for any assistance with the science content. For example the workshop craft teacher was asked by a pupil to help her build a model house, with no explanation of why. Upon questioning it was apparent that she wanted to test various materials for their insulating properties, but had not made the link that the worksh op craft teacher may be able to assist with the content knowledge too. The textiles and food technology teachers have been involved in assisting students to prepare science fair projects in the 'consumer science' section of the science fair, primarily concerned with experimenting with food and testing fabrics.

In summary some of the technicraft teachers appear to infuse science through their subjects, primarily alerting the students to it through discussion. It appears, in some cases, such as in the workshop craft room and the food technology room , science is presented in a 'real context' where if the students understand the concepts, their decorative effect or wood or the cake they are baking for example will work, and if they do not, it will not be as successful.

5.3 Classroom Teacher Self-Evaluation of Science Teaching Practice

Fifteen of the sixteen classroom teachers completed the questionnaire. Results of the 'Teacher Practice Self-Evaluation of Science Teaching' questionnaire (Appendix Two), will be presented and discussed in relation to teachers' gathering of student information, planning and assessment of science teaching, interactions with their students on a lesson by lesson basis and student investigations and the learning and application of new skills.

From the responses in Table 5.8 only one teacher said that they seek their students 'before views' in every topic, although almost all teachers claimed to seek these views in at least some topics. Almost all teachers establish the students' before views using methods other than a pen and paper test in at least some topics. Other methods used were: verbal means such as discussion, at times supported pictorially by mind maps and overviews. A contrast to this is the teacher who has children carry out investigations and test their own ideas before the unit is taught. Six teachers did not list any other methods used.

Once this level of entry knowledge has been established, only one teacher said they would use it as a basis for teaching in every topic while almost all teachers say they would use it in at least some topics. Half of the teachers say they introduce scientific skills and attitudes in a context relevant and familiar to the students in every unit while all of them report doing so in at least some topics. This level of response was interesting considering that three teachers approached the researcher to clarify what a 'context' actually was and six teachers gave no examples of contexts currently used.

In the preparation of science units only one teacher made up their own unit in every topic. Three teachers never made up their own and the remainder fell in the continuum in between. When using a prepared unit, three teachers claimed to include extra material in every topic and almost all teachers claimed to do so in at least some topics. Only one teacher said that assessment was ongoing and the pupils were involved with it in every topic. However, almost all the teachers claimed that this was happening in at least some topics.

Whilst there was a high level of compliance reported regarding planning and assessment in the at least 'some topics' range, this level dropped when entering the 'every topic' range. Therefore, when examining the self-reports of practice in the 'every topic' range, there is variance reported by the staff at Bayside, with the requirements of the curriculum. This could reflect some staff members' unfamiliarity with the approaches inherent in the science curriculum.

Table 5.8

Self-reflections on planning and assessment in science teaching

How often do you when teaching science	Frequency					
	In every topic	In most topics	In some topics	Never	No	Total
	(N)	(N)	(N)	(N)	(N)	(N)
Establish the students' 'before views'?	1	8	5	1	0	15
Establish the students' before views using methods other than a pen and paper test?	0	6	7	1	1	15
Use the students' ideas /beliefs as a basis for learning?	1	6	7	1	0	15
Introduce scientific skills and attitudes in a context relevant and familiar to the students?	7	5	3	0	0	15
Do you make up your own units?	1	6	5	3	0	15
If using a prepared unit, do you include material extra to what is provided?	3	7	4	0	1	15
Ensure that assessment is ongoing and that pupils are involved with it?	1	7	5	2	0	15

5.3.1 Student-teacher interactions

During teaching interactions in science, all responding teachers say they try to help children see the relevance of science to themselves and society in at least most lessons. Only three teachers consider that they challenge children in every lesson, while all teachers report challenging children in at least some lessons. All teachers answering the questionnaire report expecting children to achieve in at least most lessons. Seven teachers say they have a well established classroom routine in every lesson and all teachers say they have in at least most lessons. All teachers report encouraging a positive relationship between teacher and student in at least most lessons. Seven teachers say they ensure learning objectives are clear to the students in every lesson, while all teachers report doing so in at least some lessons. These data reflect a higher degree of compliance with curriculum requirements than those presented in the previous table. An explanation for this higher response rate could be that such interactions and aims are typical of a teacher's general teaching work and therefore are being applied in other areas also.

Table 5.9

Self-reflections on student-teacher interactions in science

	Frequency					
How often do you when teaching science	**In every topic**	**In most topics**	**In some topics**	**Never**	**No**	**Total**
	(N)	(N)	(N)	(N)	(N)	(N)
Try to help the students see the relevance and usefulness of science to themselves and society?	4	11	0	0	0	15
Challenge children?	3	9	3	0	0	15
Expect children to achieve?	12	3	0	0	0	15
Have a well established classroom routine?	7	7	1	0	0	15
Encourage a positive relationship between teacher and student?	12	3	0	0	0	15
Ensure learning objectives are clear to the students?	7	7	1	0	0	15

5.3.3 Investigation and skill development

As reported in Table 5.10, no teachers reported their students developing their own investigations in every topic while almost all report having students develop investigations in at least some topics. One teacher reported never having done so. Six teachers gave opportunity for students to describe what they had investigated in every topic, while all teachers allowed this in at least some topics. Three teachers reported giving opportunities for new skills and ideas to be used in a familiar context first, in at least every topic, while all teachers did so in at least some topics. Finally, only one teacher reported giving opportunities to use new skills in challenging situations later in every topic, while almost all teachers reported doing so in at least some topics. One teacher reported never having done so. A possible explanation regarding why no teachers faciliate investigations in every topic, is the level of teacher content knowledge in science in order to do this. As outlined in the literature review, teachers with less content knowledge tend to adopt more 'closed' teaching methods to compensate for this.

Table 5.10

Self-reflection on the provision of opportunities to investigate and develop skills

How often do your students	Frequency					
	In every topic	In most topics	In some topics	Never	No	Total
	(N)	(N)	(N)	(N)	(N)	(N)
Develop their own investigation to test using fair testing methods?	0	6	8	1	0	15
Describe what they have investigated and what they now understand?	6	7	2	0	0	15
Have opportunities to use new ideas/skills in a familiar context first?	3	3	8	0	1	15
Have opportunities to use new skills /ideas in challenging situations later?	1	6	6	1	1	15

5.3.4 Summary

In summary, most of the responses presented in Table 5.8 and Table 5.10, which refer to planning of lessons and opportunities to investigate and develop skills, fall in the at least 'some topics' range. The responses in Table 5.9, which focus on student-teacher interactions, are more highly weighted in the at least 'most lessons' range. It could be argued that where there is a science content-knowledge base necessary, eg in using the students' ideas as a basis for learning, fewer teachers reported doing this as frequently.

As a cautionary note, one should remember that these data were generated from a self-reflection questionnaire. The degree to which the data paints an accurate picture of practice is therefore premised on how the questions were interpreted by staff, how reliable their self-reflections were and whether they were tempted to say what was 'expected' rather than tell their reality.

While in most areas, almost all teachers say they are fulfilling curriculum requirements in at least some topics (and one could question whether this is sufficient compliance) these data expose two main areas of concern.

In view of the thrust in the 1993 science curriculum document towards investigations in science, it is concerning that no teachers have students develop their own investigations in every topic and only six do so in most topics. One could question whether this provides sufficient experience in investigation to fulfil the curriculum. In addition to this, given the emphasis on constructivist theories of teaching in the curriculum, it is concerning that only one teacher reports establishing student 'before-views' in every topic and only one teacher uses these as a basis for learning in every topic. About half of the teachers would comply with these approaches in at least most topics, but again one could question whether this level of compliance is what the writers of the curriculum had envisaged.

5.4 Summary of Teachers' Perspectives on Teaching Science

In summary, 16 classroom teachers, three management staff and four technicraft teachers are a diverse group in terms of teaching service and service at Bayside school. Most of the management and classroom teaching staff share a professional background where training in science and science teaching has not been a major focus but many articulated the perceived benefits of having more science content knowledge.

Nearly all management and classroom teachers felt positively or very positively about science teaching. This positive attitude is interesting considering the level of science expertise in the staff. It could be explained by the consistent level of support they receive from the teacher with responsibility for science. The majority of classroom teachers report complying with current curriculum science teaching practice in at least some topics. It is possible that greater knowledge of approaches inherent in the new science curriculum, more science content knowledge together with more time for planning, could enhance this to the 'most' or 'every topic' level.

The teacher with responsibility for science contrasts with the rest of the staff in his content knowledge and high personal interest in science. He models a formal approach to science teaching but can rationalise this for pragmatic reasons. The classroom teachers hold him in high regard, even if some disagree with his approach.

As a discrete group the technicraft teachers appear to augment the student's science education within the technicraft subject by discussion of pertinent science concepts related to what the students are constructing. The Principal provides strong leadership and the management staff as a whole have put in place systems to ensure there is accountability in terms of what science had been taught by classroom teachers. They implemented the compulsory science fair and badge schemes. Staff support the management by enforcing the compulsory nature of the schemes with their students, even if some have misgivings in this regard.

The teachers at Bayside School have developed attitudes to teaching science in the context of the school science culture. This culture has developed as a way of solving the school's science delivery problems or challenges. Many of the factors affecting the teachers' attitude to teaching science are a response to the factors inherent in the school science culture. Therefore teacher attitude to science can be conceived of as being influenced by and an integral part of school science culture.

Chapter Six

Student Perspectives

Results describing student perspectives are presented in two sections. The first are the attitudinal data gathered from the administration of Smail and Kelly's (1984) Science Curiosity and Image of Science inventories together with an additional open response section. The second section of this chapter presents results from focus group interviews convened to clarify trends evident in the survey information.

6.1 Student Characteristics

518 of the 593 students in the school completed the questionnaires administered. Of these 255 were form one students and 263, form two students. Females comprised 47.9% of the sample and males, 52.1%.

Table 6.1

Student characteristics by gender and form level

	Form One				Form Two				All			
	Population		Obtained Sample		Population		Obtained Sample		Population		Obtained Sample	
	(N)	(%)	(N)	(%)	(N)	(%)	(N)	(%)	(N)	(%)	(N)	(%)
Male	141	49.8	130	51.0	171	55.2	140	53.2	312	52.6	270	52.1
Female	142	50.2	125	49.0	139	44.8	123	46.8	281	47.4	248	47.9
All	**283**	**100**	**255**	**100**	**310**	**100**	**263**	**100**	**593**	**100**	**518**	**100**

In regard to ethnicity, most of those surveyed regarded themselves as European, 10% Maori or European/Maori and 10% from Asian or Asian/European origin.

Table 6.2

Student characteristics by ethnicity

	N	%
European	387	75.0
NZ Maori	3	6
Maori/European	48	9.3
Pacific Islander	2	.4
Pacific Islander/European	8	1.6
Korean	14	2.7
Chinese	20	3.9
Taiwanese	13	2.5
Asian/European	9	1.7
South African	10	1.9
Other	2	.4
Undisclosed	2	
Total	**518**	**100.0**

6.2 Student Questionnaire

A student questionnaire was devised, incorporating two attitude inventories used by Smail and Kelly in 1984; the science curiosity inventory and the image of science inventory. In addition to these, an open response section was also included at the end of the questionnaire.

6.2.1 Science curiosity inventory

Students were asked how they felt about a number of topics in science. They were asked to respond 'I'd like to know more', 'not sure', or 'not interested' by ticking the appropriate box. 'I'd like to know more' was given a score of three, 'not sure' given a score of two and 'not interested' a score of one. Mean scores on individual items were derived for the whole population and for sub-groups.

(i) Item scores

The mean scores for the total population, and form one and two students; indicating are presented in Table 6.3. Topics which gained the highest mean score, and therefore rated most highly for the whole population were 'life in the sea', 'animals in the jungle', 'drugs', 'computers', 'germs and illnesses' and 'acids and chemicals'. Those rated least highly were 'different kinds of trees', 'how vacuum cleaners work', 'how a bicycle pump works', 'what magnets do' and 'torches and batteries'. This could suggest that students as a group have more curiosity about dramatic and exciting science topics such as drugs and acids, when compared with topics which could be perceived as passive and less exciting, such as magnets and vacuum cleaners.

When the responses were analysed according to form level, a high level of interest was shown by both form one and two pupils in 'life in the sea', 'germs and illnesses', 'animals in the jungle', 'acids and chemicals' 'the stars and planets', and 'drugs'. However, 'different kinds of trees', how vacuum cleaners work', and 'how a bicycle pump works' were given low ratings by both form one and form two students. Significant differences also appeared when the responses from form one and two students were compared, frequently the form one scores were higher than the form two and were significantly so for 12 topics. The largest significant differences ($p<.001$ level of significance) where the form two score was lower than the form one score appeared in the topics 'what makes a rainbow appear' and 'light'. These were directly relatable to the form two prepared laboratory unit on Radiant Energy. The items which form two students were significantly less enthusiastic about were: 'fossils', volcanoes and earthquakes', 'acids and chemicals' 'how sound passes through air', 'different kinds of rocks', our eyes and how we see', 'computers','what magnets do','what gravity is' and 'how motorcars work'. There is no apparent reason for this. The only significant difference in which form two students scored higher was 'what food is good for you'. This could reflect their growing interest in their own bodies.

Table 6.3

Science Curiosity Inventory: Mean scores by form level

	Topic	Mean			
		Whole Population	Form One	Form Two	Sig. of * Difference
1.	How a heart works	2.09	2.04	2.16	NS
2.	Torches and batteries	1.87	1.90	1.85	NS
3.	Life in the sea	2.40	2.37	2.42	NS
4.	How a record is made	2.08	2.13	2.04	NS
5.	Fossils	.09	2.20	1.20	**
6.	Different kinds of trees	1.79	1.81	1.77	NS
7.	How insects live	1.97	2.00	1.20	NS
8.	How machines work	2.23	2.29	2.18	NS
9.	Germs and illnesses	2.36	2.32	2.40	NS
10.	How electricity is produced	2.18	2.24	2.12	NS
11.	Time	2.00	1.95	2.05	NS
12.	Our ears and how we hear	2.00	2.07	1.96	NS
13.	What baking powder does	1.95	1.94	1.96	NS
14.	Volcanoes and earthquakes	2.28	2.38	2.18	**
15.	How transistor radios work	2.01	2.05	1.99	NS
16.	Water	2.15	2.16	2.14	NS
17.	How our muscles work	2.22	2.19	2.27	NS
18.	Light.	2.13	2.27	1.99	***
19.	What food is good for you	2.26	2.18	2.35	*
20.	How vacuum cleaners work	1.67	1.74	1.62	NS
21.	Animals in the jungle	2.48	2.52	2.44	NS
22.	Acids and chemicals	2.47	2.57	2.37	**
23.	How children develop	2.06	2.06	2.06	NS
24.	Nuclear power	2.31	2.28	2.34	NS
25.	How sound passes through air	2.25	2.36	2.13	**
26.	Birds eggs and nests	1.91	1.96	1.86	NS
27.	What makes a rainbow appear	2.20	2.37	2.03	***
28.	Different kinds of rocks	2.09	2.20	1.20	**
29.	Why some animals hibernate	2.16	2.21	2.11	NS
30.	Atoms and molecules	2.06	2.09	2.02	NS
31.	Our eyes and how we see	2.17	2.24	2.10	*
32.	The star and planets	2.36	2.34	2.39	NS
33.	Drugs	2.49	2.48	2.50	NS
34.	Computers	2.46	2.53	2.38	*
35.	How a bicycle pump works	1.62	1.72	1.52	NS
36	The air we breathe	2.08	2.14	2.04	NS
37.	What magnets do	1.84	1.95	1.72	**
38.	How caterpillars change into butterflies	1.99	2.08	1.93	NS
39.	What gravity is	2.23	2.33	2.14	**
40.	How motorcars work	2.08	2.19	1.99	*
41.	The weather	2.09	2.07	2.10	NS
42.	How seeds grow into flowers	1.94	1.97	1.91	NS
	Mean	**2.12**	**2.16**	**2.08**	
	N	**518**	**255**	**263**	

T-Test: Separate Variance Estimate - 2 tailed probability. Levels of significance * p<.05 **p<.01 ***p<.001 NS=Not significant

The mean scores for girls and boys are presented in Table 6.4. The concurrence between boys' and girls' views was limited. There were a number of significant differences between these two groups which can be summarised as girls preferring topics with a human biology, environmental or health orientation. For example girls rated these items highly: 'germs and illnesses', 'drugs', our eyes and how we see', 'what food is good for you', 'life in the sea', why some animals hibernate', 'what makes a rainbow appear' 'the stars and planets'. They gave the following items low scores: 'how motorcars work', how a bicycle pump works', 'torches and batteries', how transistor radios work' and 'atoms and molecules'. While boys, like the girls, also rated an interest in 'drugs' highly, they scored significantly differently from the girls on topics which could be summarised as encompassing chemical or physical sciences. They rated these items highly: 'how machines work', 'acids and chemicals', 'nuclear power', 'how motorcars work' and 'computers'. They gave low ratings to the items: 'different kinds of trees', how insects live', your ears and how we hear', birds eggs and nests', and how seeds grow into flowers. Boys also had a low level of interest in 'how a bicycle pump works'. These trends largely reflect stereotypical responses and will be also be examined later in this chapter, using factor analysis.

When the Korean, Chinese, Taiwanese and European-Asian group responses were combined and compared with those from the European group, some significant differences emerged. These data, presented in Table 6.4, show that Asian students were significantly more positive (to a $p<.001$ level) when compared with European students on the items 'how a heart works', 'different kinds of trees', 'how insects live', 'light' and 'how sound passes through air'. They were significantly more positive (to a $p<.01$ level) than their European counterparts on the items: 'time', 'our ears and how we hear', 'drugs' 'how a bike pump works and 'the weather'. The Asian students were significantly more positive (to a $p<.01$ level) on the items 'torches and batteries', 'how machines work', 'water', 'how vacuum cleaners work', 'birds eggs and nests', 'what makes a rainbow appear', our eyes and how we see', 'the stars and the planets', 'the air we breathe', 'how caterpillars turn into butterflies' and 'how seeds grow into flowers'. These differences appear to range across the biological and physical sciences.

Table 6.4

Science Curiosity Inventory: Mean scores by gender and ethnicity

Topic	Mean					
	Boys	Girls	Sig. of * Diff	Euro - pean students	Asian students	Sig. of * Diff
1. How a heart works	1.97	2.22	***	2.09	2.46	***
2. Torches and batteries	2.13	1.58	***	1.86	2.09	*
3. Life in the sea	2.26	2.54	***	2.39	2.52	NS
4. How a record is made	2.10	2.06	NS	2.07	2.25	NS
5. Fossils	2.09	2.09	NS	2.10	2.07	
6. Different kinds of trees	1.63	1.96	***	1.73	2.16	***
7. How insects live	1.88	2.07	**	1.94	2.36	***
8. How machines work	2.60	1.83	***	2.23	2.45	*
9. Germs and illnesses	2.24	2.48	***	2.39	2.27	NS
10. How electricity is produced	2.34	2.01	***	2.19	2.34	NS
11. Time	1.94	2.07	NS	1.99	2.34	**
12. Our ears and how we hear	1.84	2.19	***	1.99	2.34	**
13. What baking powder does	1.89	2.01	NS	1.95	2.05	NS
14. Volcanoes and earthquakes	2.36	2.18	**	2.26	2.27	NS
15. How transistor radios work	2.34	1.65	***	2.02	2.20	NS
16. Water	2.00	2.32	***	2.13	2.36	*
17. How our muscles work	2.16	2.29	NS	2.25	2.27	NS
18. Light	2.18	2.07	NS	2.09	2.52	***
19 What food is good for you	2.07	2.47	***	2.09	2.52	**
20. How vacuum cleaners work	1.72	1.61	NS	2.24	2.59	*
21. Animals in the jungle	2.37	2.61	***	2.47	2.54	NS
22. Acids and chemicals	2.61	2.31	***	2.49	2.32	NS
23. How children develop	1.92	2.21	***	2.07	2.04	NS
24. Nuclear power	2.60	1.98	***	2.32	2.29	NS
25. How sound passes through air	2.26	2.22	NS	2.22	2.56	***
26. Birds eggs and nests	1.67	2.17	***	1.86	2.16	*
27. What makes a rainbow appear	1.96	2.46	***	2.17	2.41	*
28. Different kinds of rocks	2.06	2.13	NS	2.07	2.16	NS
29. Why some animals hibernate	1.97	2.37	***	2.17	2.23	NS
30. Atoms and molecules	2.28	1.80	***	2.09	1.98	NS
31 Our eyes and how we see	2.03	2.32	***	2.17	2.45	*
32. The star and planets	2.36	2.37	NS	2.35	2.59	*
33. Drugs	2.50	2.48	NS	2.53	2.21	**
34. Computers	2.73	2.16	***	2.44	2.50	NS
35. How a bicycle pump works	1.75	1.48	***	1.60	1.95	**
36 The air we breathe	1.93	2.26	***	2.08	2.33	*
37. What magnets do	1.90	1.76	NS	1.83	2.13	*
38. How caterpillars change into butterflies	1.82	2.19	***	2.02	2.07	NS
39. What gravity is	2.25	2.21	NS	2.27	2.21	NS
40. How motorcars work	2.45	1.68	***	2.09	2.04	NS
41. The weather	1.98	2.20	**	2.08	2.38	**
42. How seeds grow into flowers	1.74	2.17	***	1.92	2.20	*
Mean	**2.12**	**2.12**		**2.12**	**2.28**	
N	**270**	**248**		**387**	**56**	

T-Test: Separate Variance Estimate - 2 tailed probability. Levels of significance * p<.05 **p<.01 ***p<.001 NS=Not significant

The overall levels of interest are presented in Table 6.5 below. The mean of the means for the total population, boys , girls, and European students are identical. The mean of the means for the form two students is lower than for form one, and the mean of means for the Asian students is higher than for any of the other sub-groups, but the significance of these differences was not investigated.

Table 6.5

Science Curiosity Inventory: Overall level of interest

	Mean of mean
Boys	2.12
Girls	2.12
Form One	2.16
Form Two	2.08
European	2.12
Asian	2.28
All Students	**2.12**

(ii) Factor scores

When these data were subjected to open principal component analysis, filtered by varimax rotation, nine factors emerged. Data were not available as to how many factors Smail and Kelly (1984) found on open analysis. However in their 1984 report they discuss finding four factors. The nine factors identified from open principal component analysis in this study (Table One, Appendix 3) may be interpreted as: understanding our made world, incorporating physical science and related technology' understanding our physical lives, the natural world, which appeared on two groupings, understanding the remote natural world, technology, the environment, very unpopular items and finally items which reflect a nurturing orientation. Beyond factor four, factors represented only a two or three items each and the factor loadings were low. Also beyond factor four the percentage of variance was very low. Therefore it was necessary to analyse for four factors.

When data were converged into four factors many similarities were seen between these factor memberships and Smail and Kelly's data. Table Two (Appendix 3) displays the factors loadings for Science Curiosity Test using the Bayside data. These can be compared with Table Three (Appendix 3), Smail and Kelly's factors for the same test. Ten of the eleven factor one items are consistent with ten of the fifteen items on Smail and Kelly's physical science factor, seven of the thirteen items on the second factor matched seven of the thirteen items on Smail and Kelly nature science factor. Nine of the thirteen items on factor three matched all nine on Smail and Kelly's factor three items relating to human biology. The five items on factor four were distributed across Smail and Kelly's factors or not used in their analysis. Five of the six items on Smail and Kelly's factors were found on factor two.

Therefore, the Bayside factors, for the Science Curiosity Test, overlap with those described by Smail and Kelly. For value of comparison and because Smail and Kelly's (1984) factors were established from a much greater sample, across a large number of schools, it was decided to use Smail and Kelly's factors. The major departure of the Bayside factors from Smail and Kelly's factors lies in the appearance of the Smail and Kelly factors 'Nature science' and 'TV Science' combined, on one Bayside factor.

When the items on each factor were combined, means and tests of significant difference between groups were produced. Tables 6.6 and to 6.7 display the results . The population shows least curiosity about nature science and most about TV Science. There were significant differences between form one and two students with form one students liking physical science and nature science more than form two students. At both levels students are curious about their own bodies and the sort of science that appears on TV.

Table 6.6

Science Curiosity Inventory - Factor scores by form level

	Mean			
	Whole Population	**Form One**	**Form Two**	**Sig * Diff**
Physical Science	2.08	2.14	2.03	*
Human Biology	2.20	2.20	2.19	NS
Nature Science	2.05	2.22	1.88	***
TV Science	2.28	2.30	2.27	NS

T-Test: Separate Variance Estimate - 2 tailed probability. Levels of significance * p<.05 **p<.01 ***p<.001 NS=Not significant.

Highly significant differences occurred between boys' and girls' factor scores for curiosity about physical sciences, human biology and nature science. There were no significant difference between these groups in curiosity about science on TV. Asian students showed a significant difference in curiosity, over their European counterparts, about physical science and nature science.

Table 6.7

Science Curiosity Inventory: Factor scores by gender and ethnicity

	Mean		Sig * Diff	Mean		Sig * Diff
	Boys	**Girls**		**Euro - pean**	**Asian**	
Physical Science	1.90	2.25	***	2.08	2.25	*
Human Biology	2.31	2.08	***	2.20	2.29	NS
Nature Science	2.22	1.88	***	2.03	2.26	**
TV Science	2.30	2.27	NS	2.28	2.34	NS

T-Test: Separate Variance Estimate - 2 tailed probability. Levels of significance * p<.05 **p<.01 ***p<.001 NS=Not significant.

To compare Bayside girls' and boys' curiosity with English girls' and boys' curiosity, it was necessary to select only the form one students from the Bayside sample, since the English students were 11 years old at the time they took the test. These comparisons are shown in Table 6.8. There are some apparent differences; the Bayside girls are less curious in human biology and more curious about TV Science, and Bayside boys less curious about human biology and nature science. To test whether these differences were significant the Standard Error of the Mean was computed using the Standard Deviation for the Bayside scores. The reliability co-efficient used was .90. In all cases Smail and Kelly's results fell within this range of plus or minus the Standard Error of the Mean, indicating there was no difference seen between Smail and Kelly's data, as presented in summary form in their 1984 report, and the data generated from this study. This is interesting considering the time which has elapsed between their study in which their data was reported in 1984 and when the Bayside data was collected in 1995. This comparison was made however, on the basis of small samples of Bayside students, which increased the standard deviations and the standard error of the means and thus reduced the possibility of finding significant differences.

Table 6.8

Science Curiosity Inventory: Comparison of Smail and Kelly factor means with form one Bayside factor means by gender

	Girls				Boys			
	This study Means	Std Dev.	S & K Means	SEM test	This study Means	Std Dev.	S & K Means	SEM test
Physical Science	1.94	.42	1.89	NS	2.34	.45	2.33	NS
Human Biology	2.28	.46	2.40	NS	2.10	.50	2.21	NS
Nature Science	2.24	.45	2.31	NS	1.91	.51	2.01	NS
TV/Environment	2.37	.40	2.18	NS	2.32	.47	2.28	NS
N	**248**		**1032**		**270**		**1033**	

An additional tool of analysis is to compare significant differences between boys and girls within each data set to ascertain if differences which were significant in 1984 are still significant now. This comparison is presented in Table 6. 9. There is a high degree of significant difference in both Smail and Kelly's data and the Bayside data between boys and girls for the factors physical science and nature science. The difference between boys and girls is less significant on the human biology factor in the Bayside data, than in Smail and Kelly's, but in all these three factors, the differences are in the same direction. Smail and Kelly also found a high degree of difference between boys and girls on the factor TV Science. However in the Bayside data there is no difference.

Table 6.9

Science Curiosity Inventory: Comparison of Smail and Kellys (1984) and Bayside's form one data by gender

	This study		Sig * Diff	Smail and Kelly		Sig * Diff
	Girls Mean	Boys Mean		Girls Mean	Boys Mean	
Physical Science	1.94	2.34	***	1.89	2.33	***
Human Biology	2.28	2.10	**	2.31	2.01	***
Nature Science	2.24	1.91	***	2.40	2.21	***
TV/Environment	2.37	2.32	NS	2.18	2.28	***
N	**248**	**270**		**1032**	**1033**	

6.2.2 Image of science inventory

In this inventory, students responded to statements about science and scientists using a scale of : agree, not sure, or disagree, which were scored 3, 2, and 1. A response which indicated 'yes, I agree' scored a 3, 'not sure' scored a 2 and 'no, I disagree' scored a 1. Scores on items which expressed negative views about science or scientists were reversed. Therefore a score of 3 indicated a positive attitude, 2 a neutral attitude and 1 a negative attitude.

(i) Item scores

The higher scores on this inventory were for the items which indicated a liking for science, "science is fascinating", "I like finding out how things work", and "Science is making things better all the time" scored highly. This is shown in Table 6.10 . However, there may be a limit for this enthusiasm as indicated by a low score for "When I start thinking about science I find it hard to stop". This may have been perceived by some students as 'boffin'-type comment. Also scoring highly were items which indicated science being useful in the world "science is useful whatever you do when you leave school". Consequently items such as "science does more harm than good", scored in the lower range. Also in the lower range were comments which contained stereotyped images of scientists such as "most scientists are ugly", "scientists are always forgetting things" and "scientists never talk about anything except science". Other comments which fell in the lower range reflected science as a male stereotyped subject with boys concentrating on physical sciences as was indicated by low scores on "learning science is more important for boys than girls, "Boys don't need to know about animals and flowers", and "Girls don't need to know how things work".

When the Image of Science inventory responses were analysed by form level, interesting patterns emerged from the significant differences, (Table 6.10). Form two students appear to have a significantly lower image of scientists, for example 'scientists are boring people' and 'scientists don't seem to be happy' scored significantly lower than the form one students. Form two students have a lower perception of the of the utility of science, shown in items such as 'science is useful whatever you decide to do when you leave school' and 'money spent on science could be put to better use', on which form two students scored respectively lower and higher than form one students. When compared to their form one counterparts, form two students have a more negative image of science as a force for good in the world, as shown by significantly higher scores on items such as 'Science is to blame for killing millions of people' and lower scores on items such as 'science is making things better all the time'. The highest level of significant difference was for items where form two students found science less exciting and less fascinating than the form one students did. This was evident in items such as 'science is exciting', 'science is fascinating', 'I've always been interested in learning science', and 'when I start thinking about science I find it hard to stop'. There were significant differences between the form one and form two students in their perception of girls and science on two items: 'girls are just as good as boys at science' where the form one students had a significantly more positive attitude and 'learning science is more important for boys than for girls' where significantly more form two students agreed, even though both form one and two students scored under the 'not sure' for that item.

Table 6.10

Image of Science Inventory: Mean scores by form level

Topic	Mean			
	Whole Population	Form One	Form Two	Sig. of * Difference
1. I like fiddling with machinery	2.33	2.30	2.36	NS
2. Science is making things better all the time	2.42	2.51	2.33	**
3. Girls are very good at using tools	2.18	2.23	2.12	NS
4. Scientists do not care about people	1.43	1.39	1.46	NS
5. In science all the answers are already known	1.45	1.52	1.43	NS
6. Science is useful whatever you do when you leave school	2.38	2.47	2.29	**
7. Science is fascinating	2.50	2.70	2.30	***
8. Scientists are a bit weird	2.12	2.12	2.11	NS
9. Computers are taking over the world	2.31	2.25	2.40	NS
10. I want to learn all I can about science	2.16	2.31	2.02	***
11. A woman could never be a great scientist	1.22	1.22	1.22	NS
12. Science makes things which are a nuisance	1.57	1.50	1.64	**
13. Scientists do lots of things which are dangerous	2.46	2.50	2.42	NS
14. Science is a very difficult subject	2.23	2.25	2.22	NS
15. Science does more harm than good	1.62	1.56	1.69	*
16. It's useful to know about science when you are bringing up children	2.29	2.38	2.20	**
17. Scientists are always forgetting things	1.59	1.54	1.63	NS
18. Engineering is a dirty job	2.20	2.30	2.10	**
19. I'd like to be given a science book for a present	1.86	1.97	1.75	**
20. Girls don't need to know about electricity or light	1.19	1.16	1.22	NS
21. Money spent on science could be put to better use	1.73	q.59	1.87	***
22. Scientists should never guess what will happen in their experiments	1.79	1.81	1.76	NS
23. Knowing science will help me earn a living	2.37	2.46	2.28	**
24. Girls who want to be scientists are a bit peculiar	1.36	1.35	1.37	NS
25. Science is very exciting	2.40	2.61	2.19	***
26. Most scientists are ugly	1.61	1.53	1.68	*
27. Lots of information we get from science now will be changed in the future	2.50	2.50	2.50	NS
28. I'd like to have a job making things	2.13	2.22	2.05	*
29. Science is to blame for killing millions of people	1.90	1.76	2.03	***

Table 6.10 continued over

30. Only people who want to become scientists should have to study science	1.67	1.64	1.69	NS
31. Science is very dangerous for everyone	1.65	1.66	1.63	NS
32. When I start thinking about science I find it hard to stop	1.71	1.82	1.62	**
33. Learning science is more important for boys than for girls	1.30	1.23	1.37	**
34. Scientists never talk about anything except science	1.67	1.64	1.71	NS
35. Science is destroying the beauties of nature	1.94	1.87	2.00	NS
36. I like finding out how things work	2.53	2.63	2.43	**
37. Science teaches us not to believe everything we are told	2.06	2.05	2.08	NS
38. My father thinks I will be good at science	1.95	1.95	1.95	NS
39. The results of science are making life too much of a rush	1.93	1.87	1.98	NS
40. Science is only for brainy people	1.52	1.40	1.63	**
41. Boys don't need to know about animals and flowers	1.25	1.25	1.25	NS
42. People have managed without science for a long time and we should be able to manage without science too	1.68	1.66	1.71	NS
43. There are too many facts to learn in science	1.93	1.86	2.00	*
44. Girls don't need to now how things work	1.20	1.17	1.26	NS
45. Science is polluting the world	2.02	1.95	2.08	NS
46. I've always been interested in science	2.07	2.19	1.96	NS
47. You have to be very strong to be an engineer	1.56	1.60	1.53	NS
48 . You can't use your imagination in science	1.64	1.60	1.68	NS
49. Science doesn't affect my life	1.65	1.74	1.56	**
50. Science is making most people's jobs more boring	1.64	1.61	1.67	NS
51. I don't expect I'll be any good at science	1.84	1.74	1.93	**
52. I'd like to have an job using science	1.98	2.07	1.89	**
53. Everyone needs to learn science to understand the modern world	2.60	2.63	2.58	NS
54. Scientists don't seem to be happy	1.72	1.65	1.79	*
55. Girls are just as good as boys at science	2.75	2.83	2.68	**
56. Science is reducing our freedom	1.89	1.87	1.91	NS
57. There are too many facts to learn in science	1.94	1.92	1.95	NS
58. Scientists are boring people	1.63	1.54	1.72	**
Mean	**1.90**	**1.91**	**1.89**	
N	**518**	**255**	**263**	

T-Test: Separate Variance Estimate - 2 tailed probability. Levels of significance * p<.05 **p<.01 ***p<.001 NS=Not significant

A number of significant differences were evident between boys and girls on this scale as is shown in Table 6.11. Boys tended to score more highly than the girls on items indicating enduring science keenness, for example 'I've always been interested in learning science' and ''I'd like to have a job using science'. The boy's responses emphasised the tentative nature of science; for example on the item 'science teaches us not to believe everything we are told' boys' responses were significantly more positive than the girls. Boys were more worried than the girls in perceiving the negative effects of science, shown in items such as 'science is to blame for killing millions of people' which boys scored significantly higher than girls. The girls showed patterns of highly significant differences and were more positive when compared to the boys, on items pertaining to the suitability of science for girls. For example 'Girls are very good at using tools', 'a woman could never be a great scientist', 'girls don't need to know about electricity or light', and 'girls who want to be scientists are a bit peculiar.' In spite of this strong show of group-affirmation, it is interesting that the girls rated themselves as significantly less confident than the boys on the item 'I don't expect I'll be any good at science'.

When the responses given by Asian and European students were compared, it appeared that Asian students were significantly keener and more interested in science, as presented in Table 6.11. Their scores were significantly different and more positive when compared with their European counterparts on items such as 'when I start thinking about science I find it hard to stop', 'I'd like to have a job using science', and 'I've always been interested in learning science'. When compared to their European counterparts, Asian students had a significantly lower perception of science as a pursuit important or suitable for girls. Asian students were significantly less positive on the items 'girls are just as good as boys at science', and 'girls are very good at using tools' while they were significantly more positive on items such as 'girls who want to be scientists are a bit peculiar'. However Asian students did disagree significantly on the item 'boys don't need to know about animals and flowers'. European students were significantly different from their Asian counterparts in perceiving science as more dangerous and conducted with less imagination. The largest significant difference appeared in European students perceiving engineering as a dirty job. Asian students showed more variation in their answers when compared to European students.

Table 6.11

Image of Science Inventory: Mean scores by ethnicity and gender

Topic	Mean					
	Boys	Girls	Sig. of * Diff	Euro - pean students	Asian students	Sig. of * Diff
1. I like fiddling with machinery	1.96	2.66	***	2.31	2.36	NS
2. Science is making things better all the time	2.44	2.40	NS	2.24	2.36	NS
3. Girls are very good at using tools.	2.46	1.92	***	2.21	1.89	*
4. Scientists do not care about people	1.34	1.50	**	1.41	1.54	NS
5. In science all the answers are already known	1.45	1.48	NS	1.45	1.54	NS
6. Science is useful whatever you do when you leave school	2.39	2.36	NS	2.36	2.39	NS
7. Science is fascinating	2.45	2.53	NS	2.50	2.52	NS
8. Scientists are a bit weird	2.11	2.11	NS	2.14	2.05	NS
9. Computers are taking over the world	2.24	2.37	NS	2.32	2.25	NS
10. I want to learn all I can about science	2.12	2.19	NS	2.13	2.45	**
11. A woman could never be a great scientist	1.10	1.32	***	1.19	1.30	NS
12. Science makes things which are a nuisance	1.48	1.65	**	1.57	1.61	NS
13. Scientists do lots of things which are dangerous	2.42	2.49	NS	2.47	2.26	*
14. Science is a very difficult subject	2.19	2.26	NS	2.24	2.25	NS
15. Science does more harm than good	1.59	1.66	NS	1.60	1.80	*
16. It's useful to know about science when you are bringing up children	2.29	2.30	NS	2.29	2.41	NS
17. Scientists are always forgetting things	1.60	1.57	NS	1.55	1.73	NS
18. Engineering is a dirty job	2.24	2.15	NS	2.24	1.78	***
19. I'd like to be given a science book for a present	1.74	1.97	**	1.83	2.21	**
20. Girls don't need to know about electricity or light	1.10	1.27	***	1.18	1.23	NS
21. Money spent on science could be put to better use	1.66	1.81	*	1.70	1.91	*
22. Scientists should never guess what will happen in their experiments	1.69	1.86	*	1.80	1.60	NS
23. Knowing science will help me earn a living	2.36	2.37	NS	2.38	2.45	NS
24. Girls who want to be scientists are a bit peculiar	1.24	1.47	***	1.33	1.56	*
25. Science is very exciting	2.35	2.44	NS	2.36	2.58	*
26. Most scientists are ugly	1.54	1.65	NS	1.62	1.55	NS
27. Lots of information we get from science now will be changed in the future	2.44	2.55	*	2.52	2.52	NS
28. I'd like to have a job making things	1.93	2.32	***	2.13	2.24	NS
29. Science is to blame for killing millions of people	1.73	2.05	***	1.91	1.91	NS

Table 6.11 continued over

30. Only people who want to become scientists should have to study science	1.58	1.75	*	1.66	1.66	NS
31. Science is very dangerous for everyone	1.68	1.68	NS	1.66	1.50	NS
32. When I start thinking about science I find it hard to stop	1.61	1.81	**	1.65	2.20	***
33. Learning science is more important for boys than for girls	1.18	1.40	***	1.27	1.55	*
34. Scientists never talk about anything except science	1.69	1.66	NS	1.69	1.61	NS
35. Science is destroying the beauties of nature	1.94	1.94	NS	1.94	1.86	NS
36. I like finding out how things work	2.38	2.67	***	2.52	2.62	NS
37. Science teaches us not to believe everything we are told	1.95	2.16	***	2.09	1.89	*
38. My father thinks I will be good at science	1.91	2.01	NS	1.97	1.91	NS
39. The results of science are making life too much of a rush	1.90	1.95	NS	1.95	1.89	NS
40. Science is only for brainy people	1.40	1.62	NS	1.54	1.40	NS
41. Boys don't need to know about animals and flowers	1.10	1.37	***	1.25	1.07	*
42. People have managed without science for a long time and we should be able to manage without science too	1.64	1.73	NS	1.68	1.59	NS
43. There are too many facts to learn in science	1.90	1.97	NS	1.91	2.09	NS
44. Girls don't need to now how things work	1.10	1.28	***	1.20	1.14	NS
45. Science is polluting the world	2.00	2.03	NS	2.02	1.94	NS
46. I've always been interested in science	1.92	2.21	***	2.05	2.38	**
47. You have to be very strong to be an engineer	1.57	1.57	NS	1.56	1.64	NS
48. You can't use your imagination in science	1.61	1.67	NS	1.64	1.43	*
49. Science doesn't affect my life	1.59	1.69	NS	1.64	1.51	NS
50. Science is making most people's jobs more boring	1.61	1.66	NS	1.63	1.48	NS
51. I don't expect I'll be any good at science	1.91	1.76	*	1.84	1.80	NS
52. I'd like to have an job using science	1.83	2.11	***	1.98	2.21	*
53. Everyone needs to learn science to understand the modern world	2.58	2.62	NS	2.59	2.64	NS
54. Scientists don't seem to be happy	1.67	1.77	NS	1.74	1.70	NS
55. Girls are just as good as boys at science	2.88	2.64	***	2.79	2.45	**
56. Science is reducing our freedom	1.89	1.88	NS	1.89	1.89	NS
57. There are too many facts to learn in science	1.91	1.95	NS	1.92	2.08	NS
58. Scientists are boring people	1.61	1.64	NS	1.66	1.50	NS
Mean	**1.85**	**1.95**		**1.90**	**1.91**	
N	**248**	**270**		**387**	**56**	

T-Test: Separate Variance Estimate - 2 tailed probability. Levels of significance * p<.05 **p<.01 ***p<.001 NS=Not significant

(ii) Factor scores

When these data were subjected to open Principal Component factor analysis, filtered by varimax rotation, 16 factors emerged. (See Table Four, Appendix 3). It is unreported in their 1984 publication how many factors Smail and Kelly found on open principal component analysis. However, they did report finding four factors. The 16 factors derived from the Bayside data appear to reflect some of Smail and Kelly's four factor groupings in the initial four factors presented, but then loads a small number (one, two or three) items on each of another twelve separate factors. Beyond factor Five the variance was very low. For these reasons it was decided to channel the data into four factors and therefore have a smaller number of factors containing most of the variance. When, however, the data from this study was channelled into four factors, the factors loaded as Smail and Kelly had identified. Table Five in Appendix 3 presents the factor loadings from the Bayside data. The ten items from Smail and Kelly's factor one pertaining to the liking of science, all loaded onto the Bayside factor one. The only difference in the Bayside factor one was the item 'scientists are boring' which was present in Smail and Kelly's factor regarding the image of scientists. All eleven of the items from Smail and Kelly's factor pertaining to the image of science in the world are found on Bayside's factor two. Five of the six items from Smail and Kelly's factor pertaining to the image of scientists are present on Bayside factor three. All eight of Smail and Kelly's factor four items regarding science as male pursuit, are found on the Bayside factor four. The scale emerging from the Bayside study is almost identical to Smail and Kelly's scale (Table Six, Appendix 3). Smail and Kelly (1984), however have a number of items (denoted by an 'x') which they state "were not included in the scales but were nevertheless retained in the questionnaire because of their intrinsic value" (Pg 97). From this one assumes that these items were included in the initial factor analysis, but not used to compute later factor sub-scales.

Factor analysis of the Bayside data provide support for the Smail and Kelly factors and these have been used to compute factor means in this study. The items which Smail and Kelly did not use in their scales, denoted by '(x)' were excluded from the calculations, as they had done. Note that in the 'Science is male' scale, a high score indicates science is seen as more suitable for males than females.

The population as a whole shows a positive orientation toward science, reflected in a general liking for the subject, positive perception of science in the world and scientists. The lower score on the 'Science is male' factor indicates the population as a whole tends to disagree with the concept of science as a male construct. Form one students liked science significantly more than the form two students (p<.001) and had a significantly more positive image of science in the world (p<.01), and of scientists (p<.05), than form two students.

Table 6.12

Image of Science Inventory: Factor means by form level

	Mean			Sig * Diff
	Whole Population	Form One	Form Two	
Liking for Science	2.18	2.30	2.07	***
Science in the World	2.21	2.28	2.15	**
Image of Scientists	2.31	2.35	2.27	*
Science is Male	1.56	1.56	1.56	NS
N	**518**	**255**	**263**	

T-Test: Separate Variance Estimate - 2 tailed probability. Levels of significance * p<.05 **p<.01 ***p<.001 NS=Not significant.

Boys were seen to like science significantly more than girls. The higher mean score for boys on the Liking for Science factor indicates that the boys are more likely to see science as a masculine construct, significant at p<.01. Girls, however, had more positive perception of science as a force for good in the world, just significant at p<.05. Students of Asian origin were significantly more (p<.001) enthusiastic about science when compared to students of European extraction.

Table 6.13

Image of Science Inventory : Factor means by gender and ethnicity

	Mean		Sig * Diff	Mean		Sig * Diff
	Boys	Girls		Euro - pean	Asian	
Liking for Science	2.09	2.27	***	2.16	2.41	***
Science in the World	2.26	2.17	*	2.22	2.21	NS
Image of Scientists	2.35	2.28	NS	2.31	2.33	NS
Science is Male	1.52	1.59	**	1.55	1.52	NS
N	**248**	**270**		**387**	**56**	

T-Test: Separate Variance Estimate - 2 tailed probability. Levels of significance * p<.05 **p<.01 ***p<.001 NS=Not significant.

In order to ascertain to if there was any difference between the Bayside data and that reported by Smail and Kelly in 1984, student factor scores for form one students only were calculated, as Smail and Kelly's students were all only eleven years of age, the same age as most form one students in the early part of the year.

Tests of Standard Error of Mean were carried out using the Standard Deviations from the Bayside data. There was no significant difference between how much the boys in both studies liked science. There was also no significant difference in the girls' perception of science as a masculine pursuit in either study, indicating they are no more emancipated than over ten years ago. Girls in the Bayside study liked science less than in the Smail and Kelly's data, with the difference being outside the Standard Error of Mean while boys in the Bayside study perceived science as more suitable for girls than in the Smail and Kelly study. There was no significant difference in the way that boys and girls in the Bayside study perceived items on the Image of Scientists and Science in the world factors than the students in the Smail and Kelly study. However, in interpreting these data, the comparison is being made on small samples of Bayside students (N=248 and N=270), thereby increasing the Standard Deviations and Standard Error of Mean and thus reducing the possibility of finding significant differences. Therefore when significant differences are found, such as the Bayside girls liking science less than Smail and Kelly's girls, particular note should be taken of them.

Table 6.14

Image of Science Inventory: Comparison of Smail and Kelly factor means and means from form one students at Bayside

	Girls				Boys			
	This study Means	Std Dev.	S & K Means	SEM test	This study Means	Std Dev.	S & K Means	SEM test
Liking for Science	2.20	.46	2.38	S	2.40	.45	2.46	NS
Science in the World	2.31	.40	2.36	NS	2.24	.43	2.25	NS
Image of Scientists	2.38	.37	2.46	NS	2.34	.48	2.37	NS
Science is Male	1.52	.16	1.34	NS	1.59	.27	1.78	S
N	**248**		**1032**		**270**		**1033**	

When significant differences within data sets are examined, one can see that differences which were significant between boys and girls in the Smail and Kelly study are not as significant for the s ame age group within the Bayside study. Highly significant differences between boys and girls were found in Smail and Kelly's study for the perception of science as a force for good or evil and for the image of a scientist as a person. However, there were no significant differences between boys and girls on these factors in the Bayside data. Differences between boys and girls liking science and perceiving it as a masculine pursuit were slightly less significant in the Bayside data than in Smail and Kelly's study.

Table 6.15

Image of Science Inventory: Comparison of Smail and Kellys (1984) and Bayside form one gender difference data

	This study		Sig * Diff	Smail and Kelly		Sig * Diff
	Girls Mean	Boys Mean		Girls Mean	Boys Mean	
Liking of Science	2.20	2.40	**	2.38	2.46	***
Science in the World	2.31	2.24	NS	2.36	2.25	***
Image of Scientists	2.38	2.34	NS	2.46	2.37	***
Science is Male	1.52	1.59	*	2.18	2.28	***
N	**248**	**270**		**1032**	**1033**	

T-Test: Separate Variance Estimate - 2 tailed probability. Levels of significance * p<.05 **p<.01 ***p<.001 NS=Not significant.

6.2.3 Open response results

On the final page of the booklet containing both the Science Curiosity inventory and the Image of Science inventory was an open response section. The students were issued with the invitation: "If there is anything else you would like to add about science and/or science at Bayside School, you can write it in the space below :"Of the 518 students who participated in the survey forms, 233 responded (45%). The highest number of comments contributed per student was six, given by five students. Most of those who commented in the open response section, made one comment, with decreasing numbers making two, three four and five comments.

After reading and coding the responses, they appeared to fall into three general groups. One group of responses related to 'general' comments, another pertained to teaching approaches and third referred to specific likes and dislikes within the subjects of science. In each case the frequency of response is presented and then shown as a percentage of the students who had opportunity to comment. (i.e frequency divided by 518, multiplied by 100.)

In this first 'general 'section, the positive comments about science in general, at Bayside school and science's usefulness, outweigh the negative comments made. This is shown in Table 6.16

Table 6.16

Open response section: General comments

	Frequency	Percentage of Popn.
General positive comment about science	48	9.3%
General negative comment about science	23	4.0%
Positive comment about science at Bayside	19	3.7%
Negative comment about science at Bayside	12	2.0%
Concern about science's effect on environment and animals.	13	2.5%
Positive comment about science's usefulness.	24	4.6%
Reference to a future occupation.	7	1.4%
Relevance of scientists' activities questioned.	1	0.2%
Girls can do science as well as boys.	9	1.7%
Science should be optional	6	1.2%
Science is weird.	1	0.2%
Some things are easy to learn and some are ∂ hard.	3	0.6%
Relationship between understanding and enjoyment.	4	0.8%
Relationship between interest/fun/excitement and enjoyment.	3	0.6%
Total number of comments	**173**	

While the percentages of most responses are very small, the nature of the responses is illuminating. The positive comments ranged from general ones to questions specifically related to the school.

> "If it wasn't for science the world would be boring. I think science can be good and bad good because we have power and if it weren't for power the world would be a dull place. It is also bad because of the bombs and guns witch make the world a worse place so in conclusion I think it is OK And I like all the questions we were asked." (S009.1b).

> "Science is a very main item at (Bayside) School and it teaches us a lot as we have Science Fair, Science Extension and science in class. Well done (Bayside)." (S133.1g).

In the open response section, the enthusiasts and those who disliked science had opportunity to vent their feelings:

> "Science is one of my favourite subjects. I think Bayside should have more science work and less of other unnecessary things like singing. Because all that time wasted on singing we could be learning. I think science is the most important subject because otherwise we won't get any wear in life" (S102.1b).

> "I personally hate going to science because the school science room is old and rundown and whenever I think of science I think, BORING!" (S016.2b).

One respondent gave a lengthy argument as to his view of the importance of science:

> "Science at Bayside is all right but the science room is very old and used and needs to be replaced. Also I think there should be more science in school since we have Not been to the science room all term. Science is one of the most important things to learn. It is more important than English or spelling. Right now I think people are quite sexist about science and do not know that science is for everyone. When I listen to people talk about science in this room I honestly think that they, and what this school has for science is pathetic - people don't even know there are Nine planets in the solar system! I think there should be a lot more science at school because science is so important." (S221.2b).

There was a sizable group of students who felt concerned about the effect of science on animals and the greater environment:

> "Most of the time scientists make bombs and test them out witch is destroying the world because they are now starting to test them underground and the news people say that the sea water might go into the explosive place and then go back out and the fish might get hurt because of the bad stuff under there." (S049.2b).

> "I think science is fun but when it is used on animals some people hurt there animals, I now we have rulls but I think they need to be made stronger and expland why." (S111.1g).

A number of responses referred to the relationship between understanding and enjoyment as well as referring to science being fun and interesting:

> "Science is more fun and interesting when there are experiments. Science is important" (S034.2g).
>
> "It is interesting doing experiments and it is fun wondering about what will happen after the experiment" (S297.2.b).
>
> "Sometimes when a teacher is explaining things to you he/she does it in a way that we don't understand. When I actually understand what I am doing I find science more fun". (S020.2g).

Students were quite forthcoming with suggestions regarding the teaching of science at Bayside school. They focused mainly on wanting more hands-on activities, less writing, more science time, more in depth study with one group complaining that science was too complicated. These reports are summarised in Table 6.17.

Table 6.17

Open response section: Comments pertaining to teaching of science

	Frequency	Percentage of Popn.
The science room is well equipped	5	1.0%
Want choice of activities and topic	4	0.8%
We have lots of choice	1	0.2%
Separate boys and girls science classes.	1	0.2%
More access to science extension is necessary	5	0.97%
Too much writing in science	10	1.9%
Too much discussion in science	1	0.2%
It is taught in a boring way	4	0.8%
Want more hands on/exciting/fun activities	25	4.8%
Like using hands-on things and doing experiments	5	1.0%
Want more science time	18	3.5%
More science time ... should go to science room more often	4	0.8%
More science learning	5	1.0%
Science as a Technicraft subject	3	0.6%
Should have more interesting topics	9	1.7%
Science should be more in depth	4	0.8%
It is too hard/complicated/I don't understand	11	1.1%
I'm not good at science	4	0.8%
I want to be shown how things work and told things/facts	3	0.6%
Positive about science badges	2	0.4%
Negative about science badges	1	0.2%
Positive about science fair	8	1.5%
Negative about science fair	3	0.6%
Science fair should be optional in Form 2	6	1.2%
More time needed on science fair	1	0.2%
Each class should have allocated science room time	1	0.2%
Should have specialist science teacher	2	0.4%
Lab work too easy and repetitive from primary school and form 1 stuff in form 2	5	1.0%
Total number of comments made	**166**	

One form two girl commented:

> "Overall at Science at Bayside School is excellent, considering the facilities and limited supplies and money that the school has. I think it could be made more interesting, by instead of doing lots of bookwork and writing everything down we could be shown how things work and do some models. Science could also be made more interesting by covering a lot more topics and having three blocks of science a week regularly" (S075 .2g).

> "Science is quite interesting but we should have more say in the topics chosen. I'd like to look into topics which don't have much information already found out, so to let us use our imagination" (S195.2g).

> "Science at Bayside is interesting like colour perception. We do not do many experiments that we want to find out. We just do set experiments." (S180.2b).

> "I think we all should be able to do more science and have more fun doing experiments." (S164.1g).

In some responses calling for more science it was evident that the science room, for some students is synonymous with doing science:

> "Their should be more science in our school because we only go about once a month." (S211.2b).

There was some strong feeling shared about equity of access to science extension opportunities:

> "Even if you're not so good at science, but like doing it you should be able to be in Science Extension because only brainy people get chosen." (S177.2g).

There was also a group of students who felt negative about their ability in science:

> "I reckon that I will never be very good at science although I wish I was given a better chance to try". (S023 .1b)

The largest group expressing their 'wants', in terms of specific subject areas within science, are those who want chemistry and the physical sciences, as presented in Table 6.18.

Table 6.18

Open response section - Like/dislike specific parts of science

	Frequency	Percentage of Popn.
Want to learn about human biology	4	0.8%
Like/want to do chemistry	18	3.5%
Like physical sciences	16	3.1%
Want to do more on the environment	2	0.4%
Want to learn more about home appliances	1	0.2%
I want to make bombs	7	1.4%
I want to learn more about animals and plants	8	1.5%
Want to learn about medicine and diseases	2	0.4%
I want to learn about evolution.	1	0.2%
More astronomy	3	0.6%
I want to construct things	2	0.4%
Want to learn about science in everyday life	1	0.2%
I don't want to learn about biology	6	1.2%
I like fossils/rocks	1	0.2%
I want to do dissections	9	1.7%
I Like using the lego	3	0.6%
I like using computers in science	3	0.6%
Total number of responses	**80**	

The group who want chemistry and the physical sciences could have a relationship with wanting to participate in the 'dramatic', to blow things up or be an active agent on the world around them, as this student demonstrates:

> "Are we allowed to mix different things and see what happens. Are we allowed to burn and electrocute things. Are we allowed to explode and implode things. Can we carve things with electricity. Can we see what happens when you do things to other things like blow torching cloth and feathers." (S190.1b).

The call for dissections may also satisfy this desire for the dramatic and novel:

> "Science is fun but the science fair is a drag (Boring!). I'd like to dissect deer lungs, frogs ox heart and many more". (S064.2b).

6.3 Focus Group Interview Responses

Six focus groups were convened in order to clarify and draw out information gleaned in the survey data. The single-sex groups of 3-4 students functioned well, initially allowing each other the opportunity to contribute individually before participating as a group and openly sharing their ideas in a discussion format. The responses generated by the focus groups to the questions posed will be presented in three sections. Initially the responses focusing on what the students found enjoyable, exciting, interesting and boring in science will be presented , followed by their notions of what it is to understand in science and in the third section details pertaining to science they conduct at home will be presented.

6.3.1 What students like in science

When the groups of students were asked to describe what they liked doing in science and why, their responses fell into two main sections. The liking of a specific subject within science and comments regarding processes or practical engagement in science activities.

The predominant subjects mentioned in conjunction with the enjoyment of science were electronics, electricity and chemistry. It should be noted however, that form two students were undertaking the prepared Chemistry unit in the school at the time of the interview which may account for this topic being frequently referred to.

Every group interviewed discussed their enjoyment of practical engagement in science using terms such as 'things that go', 'experiments', 'practical' and 'problem solving'. The principal reasons for their enjoyment of practical engagement in science appear to be an eagerness to be active in mind and body. Four of the groups interviewed stated they enjoyed 'hands-on' activities. Four groups also stated that they enjoyed not knowing what was going to happen and liked guessing what might happen. Four groups expressed their preferences in terms of a comparative statement, claiming that practical work was more interesting than copying writing off the board. In some cases it appeared that practical work and written work were conceived off as the only two alternatives.

An interesting gender difference is that more girls than boys stated they enjoyed not knowing what was going to happen and enjoyed guessing what an experimental outcome may be. In addition more girls than boys spoke of enjoying 'hands-on' science. The patterns in these responses could genuinely reflect the feelings of the small sample group interviewed or could also be accounted for by the articulate nature of the adolescent girls interviewed. Comparatively, the girls were more adept at reflecting on their learning experiences and articulating them than their male counterparts. When asked to comment on things they didn't like doing in science, five out of the six groups interviewed stated that they disliked written work. All of the groups said written work was boring and three groups argued that written work did not promote learning.

> "I don't like writing down either ... I think that the kids who just rush to get it all down ... they don't take any of it in or think about what they are writing, they are just copying it all. And because if you do an experiment, you are interested because you can see what is happening ... if you are writing down, you are writing down what the teacher says or what the book says ..." (FGS16.1g).

Most of the form two girls stated that they did not like 'putting things together'. This included electrical energy experiments, lego and what they termed 'engineering' activities. These were perceived as boring and as not experimental but construction-orientated. The cluster of form two girls who voiced anti-lego sentiments later stated that is was 'too young' for them.

When asked what fun or exciting activities or experiments were, responses could be grouped into three main themes. Five groups reported that making things react, change and seeing a result made activities and experiments fun and exciting. Four groups said that the 'hands-on' component had the same effect. Five groups commented on gaining excitement through finding things out things for themselves, through doing activities, not through books or teachers.

When asked what they perceived as being interesting experiments or activities, the strongest theme from students was to base the experiments or activities around something new, different or novel that they wouldn't normally do.

> "'Interesting' is something that you wouldn't usually do or think of ... like making popcorn you can do at your own place ... but something that you wouldn't usually think of like ... mixing two chemicals". (FGS 12.1g).

Some examples given of novel or different activities were dissecting frogs and experiments with test-tubes. When examining the overall type and range of responses to this question, it could be argued that most responses to this question align with a search for challenge. Together with the three groups already described who wanted novelty, others found experiments interesting when they found out something they didn't know, when they didn't know what was going to happen and when they found out for themselves. It appears that these students are not content with repetition.

> "Say if you are doing ... if you went to one lesson in the science room and you were connecting wires ... well the next time you are doing that as well. You should go onto new subjects each time ... like with lego or something and putting the wires in the lego". (FGS 4.1b).

Generally, all the groups appeared to want cognitive challenge.

> "John: Yeah, and it's like when they tell you an experiment and you've practically done it in your home ... like when you boil something and it evaporates ... and you'll be thinking ... this is very boring because I already know this ... Craig: It is something that your brain is used to ... John: Yeah, and what you really should be doing is designing your own experiments ... you should be told that someone wants to find out how long it takes to evaporate ten mls of water and then they want to research it ... and then you should be able to make an experiment of your own....." (FGS2 .2b & FGS4.2b).

When asked to discuss a boring activity or experiment four groups expressed the view that it was boring when they couldn't find things out for themselves because the teacher told them or showed them and reading things that other people have already discovered. When examining the range of responses to this question, there appears to be a yearning to be challenged as evidenced in the responses which emerged: 'it's boring if it is too easy' and 'it's boring if it is repeated over and over'.

> "Because in the book like if you are researching, it's facts ... but if you are experimenting, then you can write down what actually happened in your experience, not anyone elses ... but in books you are writing down that other people have done ..." (others murmur and nod) (FGS8.2g).

There appears to be pairings of concepts with regard to which students like in science. A 'boring' activity appears to equate to there being no challenge involved and an 'exciting' activity incorporates challenge.

The focus then shifted from experiments and activities to topics. There was a wide spread of opinion on the question of what was a fun or exciting topic. Strongest support , from three focus groups, was voiced for something that was different and could not be done at home, followed by a topic in which there is choice. The Form Two boys' focus group assured the researcher that within a fun topic there had to be a 'danger element' in the experiments:

> "John: And I reckon an experiment has got to have the danger element in because then people think ... oh cool ... I want to do this and we better do it right or we might loose our hand or something ... Craig: But you sound like the French because their experiment has a danger element and it's going to kill all of us (chuckle)". (FGS 6.2b & FGS 8.2b).

One focus group noted the individual nature of what makes a fun or exciting topic as some saw it dependent on individual interests and gender. One girl commented:

> "Like I said before, I think it depends on the person ... if it is a boy or a girl, like boys seem to like pulling things apart and that, and finding out what is inside them. Girls ... well ... personally me ... I like doing that too ... to a certain extent before it becomes boring after you have done it too much." (FGS 10.1g)

Two focus groups expressed the view that interesting topics were the same as fun topics. Two group also thought that having choice within the topic, and seeing personal relevance in the topic made it more interesting. Boring topics were seen as those which were too easy or repetitive and those without any personal relevance to the student.

6.3.2 Student perceptions of understanding in science.

When students were invited to share something they understood in science and explain how they knew they understood it, all groups interviewed said they knew they understood when they had experimented, made it, or when they 'could do it'. Two focus groups of girls claimed they understood something because the teacher had explained it to them and they had researched it in books. One group of girls also said they understood because a worksheet had told them and those who understood because a book had told them. This does not implicate the learner in an active role and were all made by female participants. In comparison all of the focus groups of boys interviewed responded that they understood because they had 'done' something. Three focus groups of students claimed understanding on the basis that it was in their memory for them to access at a later time:

> "I think I know it is in my head because it is there all the time ... if I went away from doing magnets and came back in a week, months or whatever later, I'd know how to do it ... and that is how I know I understood it back then". (FGS 16.1g).

Three focus groups said they knew they understood because they could explain their learning to someone else:

> "Um ... well I think you know you understand it when you can ... you know how we had had to give a speech to the science fair information evening, well I knew I could understand about my last year's science fair project because, like telling all my relations on the phone, I could just keep telling them about it. I could spend ages just talking about it ... because I knew all that was on my boards ... i could always remember it." (FGS 17.2g).

As a group, the three form two girls who had been involved in Science Fair projects for two years in a row, presented more of an orientation to deeper learning and articulateness in reflecting on their experiences of understanding. This quotation, in which pseudonyms are used, also is indicative of the group synergy that this focus group generated:

> "Jane: Well you sort of know you understand it when, like Kelly said, you can talk freely about it and you've worked so much on it that it is stuck in your head.
>
> Researcher: What do you mean by 'stuck in your head'?
>
> Jane: That you couldn't get it out if you wanted.

All: Yeah

Jane: It's there!

Anita: It's in your memory now.

Lisa: Yeah ...

Jane: ... it's like you have done so much work on it that ...

Anita: ... it's in your long term memory probably ...

Lisa: ... spent ages on it ...

Jane: ... 'cause you spent so long on it that you'll really never forget ...

Anita: ... what happened ...

Jane: ... and how it happened and how you did it and how you made it work ...

Lisa: ... yeah ... "(FGS 17 & FGS 18 & FGS 19 form two girls)

When asked how they felt when they understood something in science, all students interviewed, with the exception of three commented positively. The exceptions were all Form Two students, one boy who reported himself as 'neutral' and two girls who felt 'relieved' when they understood. Even among the remaining positive responses, there appeared a range. While most felt 'happy', some reported feelings of pride, achievement and feeling knowledgeable. A Form One girl gave an interesting account when asked to describe how she felt when she understood something in science:

> ".....proud ... because I have gained a new part of knowledge and I will be that much wiser next time someone else needs help ... on that subject and I can give them that little bit extra that might help them make it to the next level of the next step of that problem ..." (FGS 11.1g).

When discussing how they knew when they didn't understand something in science, three groups referred to failure to participate with competence. Students who couldn't answer questions, successfully complete an activity or interpret the language of the discipline perceived these as indicative of not understanding.

Nicola: "I don't understand when the pool guy comes around to check the chemicals in our pool and they use all this high tech language and him and my Dad are talking and I don't know what they are saying or anything ...

Researcher: "How do you know you don't understand?"

Nicola: "Because he tells my Dad how much and what sort of chemicals and I tried it once and I kind of mucked it up....." (FGS 12 form one girl)

Two other groups commented that aspects of science were not understood if they had not 'done' it, 'learnt' it, read about it, researched it or been told about it. One focus group reported feeling 'muddled' when they didn't understand and discussed not knowing what was happening and why it was happening. When they don't understand in science the focus group participants reported a range of feelings, all negative in nature. At one of the continuum some reported passive feelings of being left out, feeling worried and stupid. Some reported frustration. A cluster at the more aggressive pole of the negative feeling continuum reported feeling angry and annoyed. One focus group of form two girls directed that feeling at themselves and some at their teachers:

> Sandra: "You feel annoyed that no one is going to spend the time explaining it to you if it not on the sheet ... you feel annoyed that the teacher doesn't even seem to understand why it is changing because she is not explaining it to you. If they are teaching this subject, they should know what is going on. If they don't explain it to you then it seems like they don't know....."
>
> Cathy: "Well the teacher is just reading it from a sheet, so I don't really think she knows that much about it and you fell a bit annoyed that you don't know what is going on. ..." (FGS 20 & FGS 23 form two girls).

When questioned regarding the strategies employed when they don't understand science, four groups interviewed reported asking a friend or someone sitting next to them first, before asking a teacher. The reasons given for this pertained to the teacher being seen as too busy and that the teacher may think the student wasn't listening well initially. One focus group students reported that they would ask the teacher first as they saw their classmates as having an unsatisfactory knowledge base. Pretending one understood and sitting quietly or mucking around was an option exercised by another group.

The role of the teacher was described as being instrumental to the understanding of science lessons by five of the six groups interviewed. However, in describing a lesson that they had understood well, some conceived the teacher's role differently from others. For some, clear understanding was promoted by the teacher's clear delivery of exactly what to do:

> "I found in the science room when we did two experiments, one with magnets and on with magnets and circuits ... before we did each one the teacher went over it with us and showed us how to do it ... showed us different circuits and then we had to make circuits on our own. I knew how to do it and got off to a good start because the teacher went over it with us." (FGS 4.1b).

Others required the teacher to explain why the outcomes of experiments happened as they did. The focus group of form two girls who had two years of Science Fair experience, appeared to view teacher input as integral to building understanding but in a more independent way. They viewed the teacher's role as a provider of structure and guidelines from which they can work independently. In reflecting on this transcript, while much of the rhetoric focuses on independence, there is still a focus on the central nature of the teacher to building understanding.

"Lisa: I like it when the teacher gives you a guideline of what to do ... but you can still do whatever you want inside a guideline ...

Jane ... or if she gives you an example you can use ... you can jot that down so you know what to do ...

Lisa: Yeah ... make up your own ...

Anita: Or if the teacher tells you ... guideline things and then the teacher says ... now you can go and make sure you know it too ... do it yourself and take your own notes ...

Lisa: Yeah , instead of copying notes off the blackboard

Anita: Or just a few notes to give you a base ...

Jane: Is she doesn't write it all on the blackboard, but just reads it to us ... well not reads it, but tells us what we are meant to be doing ..." (FGS 17.2g & FGS 18.2g & FGS 19.2g).

Next to lessons where the teacher played a central role, 'easy' lessons were understood well. In the case of the form one boys, circuits, for example were understood because the content was familiar and repetitive. Two form two girls reflected that 'easy' lessons, such as lego compared with chemistry, meant that the teacher was not as involved with controlling the class and therefore had the time to explain. Also, in their view, the teacher had more content knowledge of the easier areas and so could explain more. The form two boys reported understanding hand-on lessons and a small cluster of students commented that well-labelled diagrams, charts, simple labelled equipment and more detail on the prepared lessons sheets would aid understanding of science lessons.

6.2.3 Student participation in science in their own time.

When asked to describe any science they did in their own time, four groups interviewed discussed science badges they had completed. Interestingly all but one of these groups were from form one. There was evidence that some of these students were extending on the activities of their own accord at home, after the completion of the badge:

"Anita: I enjoyed doing the Home Chemistry Badge at home and afterwards, when I had finished the badge, I went back and tested different drinks out ... putting different cordials and things with it ... to see if it went fizzy ...

Jane and Lisa: I did that too!.

Anita: ... to see which tasted best ..." (FGS 17.2g & FGS 18.2g & FGS19.2g)

There were also two focus groups of girls who discussed baking and cooking in relation to science at home. Three groups discussed participating in exploratory activities in informal contexts at home. For example, taking apart an old television and walkman to see what was inside, burning methylated spirits on the driveway and cutting up flowers.

Others explored using more formalised equipment such as electronics and chemistry sets, lego and microscopes. The numbers of those who explored using informal or formal equipment were split evenly in terms of gender.

The most exciting science activity conducted in their own time were the science badges with the home chemistry badge mentioned the most frequently. This was followed closely by baking and cooking as a science activity. Three groups reported encouragement from the adults at home when they are pursuing science activities there. The form two boys group said that the adults only gave their support if it was safe, while a form two girls group noted that their parents neither encouraged nor discouraged them. In discussing science activities pursued at home, the active interest of some parents was interesting:

> Lisa:" Mum and I we like to compare different brands of things ... one week she will buy 'Handy' paper towels and next week she will buy a different type and we will try to work out which is the better type. We try two different types of peanut butter and find out which one we like the best. After the science fair ... well Mum, she went around all the projects and decided she was going to try all the products that they were saying were good ... and we tried them all and ... I think that we use science quite a lot ... because it is in everyday life ..."(FGS 17.2g).

General comments at the conclusion of the focus group interviews did not form any firm pattern. However, views were expressed by one focus group about the importance of being interested in the topic of study in science and the influence that had on whether learning took place. Another group voiced a preference to have science as a specialist subject with a specialist teacher and more advanced material. There was some concern in the form two girls extension group regarding gender issues in science:

> "Anita: There is that attitude that boys are better than girls at it and that annoys me ...
>
> Jane and Lisa: Same ...
>
> Anita: It depends on who you are and what you enjoy and whether you are better at science or if you are better at history or language or something ...
>
> Lisa: Yeah...
>
> Anita: So you can't really put a rule that boys are better than girls ... or that you are too young and you have to wait until you are older ...
>
> Jane: There is no point in waiting until you are older because you might as well experiment when you are younger and then you can get further when you are older ..." (FGS 17.2g & FGS 18.2g & FGS 19.2g).

6.4 Summary - Results Describing Student Perspectives

The questionnaire surveys reflected a generally positive attitude towards science. The students rated the area of human biology and the 'TV science' factor highly, compared with other areas of science. Girls preferred human biology and nature science more than boys, whilst boys showed greater enthusiasm in the physical science area. Boys were more likely to perceive science as a masculine construct and be more cynical, as were the form two students, about the effect science has on the world. A trend evident through both inventories was that enthusiasm for science dropped significantly between the form one students and those in form two in their general liking for science and in particular physical and nature science. Students of Asian origin show a higher liking of science generally than European students, especially of physical and nature science.

While results from the whole Bayside population appeared positive, when the results from Smail and Kelly's 1984 study were compared with the equivalent form one population, it raises some areas for concern. Girls at Bayside liked science significantly less than girls over ten years ago and perceived science as a male pursuit no differently from Smail and Kelly's girls. Bayside boys however, saw science as more suitable for girls, than their counterparts ten years earlier. Boys and girls like physical science, nature science and human biology now to the same degree as boys and girls did ten years ago. There was no difference between the Bayside data and that of Smail and Kelly's in how boys and girls perceived scientists and science as a force in the world. However, in making this comparison, it must be remembered that Smail and Kelly's students were attending secondary school at age eleven in England, and would have done more science than their New Zealand counterparts.

Those who commented in the open response section of the questionnaire appeared positive about science and its usefulness, although there was concern about the effect of science on animals and the environment. There were some thoughts articulated regarding the relationship between positive attitude to science and understanding the subject and liking science and having fun. Those who responded in this section appeared assured in asserting improvements such as more science, more hands-on activities and less writing. Specifically physical science and chemistry were popular topics which some students wanted more of.

These trends were further explored in the focus group interviews. Those students interviewed appeared to enjoy that which was novel and challenging in science lessons. They were not content with activities they perceived as being repetitive, too easy, able to be carried out at home and lacking in personal relevance. Within themselves there was an eagerness to be physically active in hands-on activities and cognitively active, working out results for themselves without teachers or books telling them the answers. This has interesting implications for teachers' teaching style. The students also appeared enthusiastic to be an active change agent on materials and to see the results of those interactions.

In contrast to the independence shown when discussing what they enjoyed in science, when discussing understanding, half of those interviewed saw the teacher as instrumental. Their conceptions of understanding ranged from a surface orientation to conceptions of deeper learning. All of the boys said they understood things as a result of doing them. All of the students felt positive when they understood science and negative to various degrees when they failed to understand. For most, not understanding meant they could not participate in science with competence.

When participating in science activities in their own time, science badges featured largely as the most exciting activity undertaken, as did cooking and baking. Some students explored science using informal equipment and some had access to more conventional equipment such as electronics sets. The relationship of the home to the pursuit of science activities is another interesting emergent theme which will benefit from discussion in relation to the literature in the final chapter of this research.

Like their teacher counterparts, the students at Bayside have attitudes to science which have been influenced by factors present in the school science culture. The culture has developed as a way of solving science delivery problems and factors within it are perceived both positively and negatively by the student population. Therefore student attitudes to science are both influenced by and an integral part of school science culture.

Chapter Seven

The culture of science and its relationship with students' and teachers' attitudes to science

Initially, this chapter will draw on findings from the three results chapters to discuss the culture of science at Bayside school. Then links between this and teachers' and students' attitudes to science will be articulated.

7.1 The Culture of Science at Bayside School

During the course of this research, the 'way of life', beliefs and rituals of science at Bayside School have been illuminated through document analysis, teacher interview and questionnaire, pupil interview and questionnaire. These tangible expressions or manifestations (Beare and Millikan, 1989) of school science culture point to the intangible values underpinning Bayside science culture. Together these values embody school science culture.

In total, the values point to an oft-used metaphor in regard to science within the Bayside setting, that of a 'well-oiled machine'. The 'machine' has been established to support what has been perceived as teachers' traditionally weak areas of science teaching, that of the physical world. Much of the 'drive' for this machine, and emphasis in the physical science area comes from the Teacher with Responsibility for Science. As well as his 'drive' there appears a number of other 'driving forces'. Public image and success in science is a driving force which has determined how science is organised at Bayside. Four central values have been identified. In order to graphically depict the data supporting each value, four triangulation charts (Poskitt 1989) have been prepared. These are presented in Tables 7.1. to 7.4.

Table 7.1 presents the triangulated data for the underpinning value: A predominately traditional view of science. This value was manifest through the teacher-directed, formalised nature of the support which is not in a student context. This manifestation received support from the greatest number of data sources. This was followed by, support only in the material and physical world with little opportunity for student own investigation identified as expressing a predominately traditional view of science. Emphasis on 'the' scientific method was a manifestation of the value verified by two data sources. The mainly traditional value was also manifest in teachers not being well educated in current science curricula. This received support from three data sources. However, it is not totally traditional in approach as Bayside does advocate hands-on science activities, a manifestation of the value supported by three data sources, and students want more hands-on science, supported by two data sources. Lack of teacher preparation time may militate against this, however.

Table 7.1

Triangulation of value: 'Bayside's predominately traditional view of science'

	Data Sources					
	Teacher Interview	Teacher Q/aire	Student Q/aire	Student Interview	Document Analysis	Values Suggested by staff
Reported in:	Ch 5	Ch 5	Ch 6	Ch 6	Ch 4	Ch 5
Value manifest through:						
Tangible support for Material and Physical World	X				X	X
Prepared lessons teacher-directed	X		X		X	X
Prepared lessons not in a student context	X		X		X	X
'The' scientific method	X				X	X
Little opportunity for student own investigation	X			X	X	
Teachers not well educated in science content knowledge or current science teaching methods	X	X	X			
Lessons promote hands-on science	X				X	X
Students enjoy hands-on science the can do independently and want more of it			X	X		
Time issues	X			X		

Table 7.2 presents the triangulation of the value: Strong leadership. Each expression of this value received support from two data sources. The importance of accountability and the strong ownership/leadership demonstrated by the teacher with responsibility for science are manifestations of the value of strong leadership in Bayside science culture.

Table 7.2

Triangulation of value: Strong leadership

	Data Sources					
	Teacher Interview	Teacher Q/aire	Student Q/aire	Student Interview	Document Analysis	Values Suggested by staff
Reported in:	**Ch 5**	**Ch 5**	**Ch 6**	**Ch 6**	**Ch 4**	**Ch 5**
Value manifest through:						
Accountability is important	X				X	
Strong leadership/ownership of science	X					X

Table 7.3 presents the triangulation of the value: Emphasis on outside schemes. The two manifestations of the value received support from three data sources. The emphasis on the science badge and fair scheme and the high level of community interaction and expectation of parental support around the science fair was seen as manifesting the value of emphasis on outside schemes.

Table 7.3

Triangulation of value: Emphasis on outside schemes

	Data Sources					
	Teacher Interview	Teacher Q/aire	Student Q/aire	Student Interview	Document Analysis	Values Suggested by staff
Reported in:	**Ch 5**	**Ch 5**	**Ch 6**	**Ch 6**	**Ch 4**	**Ch 5**
Value manifest through:						
Emphasis on science fair and badge schemes	X				X	X
High community interaction and expectation of parental assistance	X			X	X	

In Table 7.4 the triangulation for the value: competition is presented. Each manifestation of the value received support from three data sources. Selecting off able students for extension activities and the emphasis on public image were both perceived as tangible manifestations of the value of competition.

Table 7.4

Triangulation of value: Competition

	Data Sources					
	Teacher Interview	**Teacher Q/aire**	**Student Q/aire**	**Student Interview**	**Document Analysis**	**Values Suggested by staff**
Reported in:	**Ch 5**	**Ch 5**	**Ch 6**	**Ch 6**	**Ch 4**	**Ch 5**
Value manifest through:						
Selecting off able students for science extension				X	X	X
Competition and public image	X				X	X

Therefore the organisational culture identified is one where there is strong leadership evident and 'systems' put in place by the science leader, in the form of prepared science lessons. The emphasis in the organisational culture is on the physical science area and science investigation in manageable 'packages' such as those provided by science fair and science badges. Interacting with these systems are teachers whose science content knowledge and teaching methods are not as strong as one would hope. The students, who appear to have a generally positive attitude to science, are articulate and forthright in their demands, wanting more science but with additional hands-on activities they can do independently. The parental and community support also provides impetus for such systems and competitions to continue and thrive.

7.2 Relationship Between Organisational Culture of Science and Teachers' and Students' Attitudes to Science

Key findings in the three main results chapters, indicate relationships between the organisational culture of science in Bayside school and the teachers' and students' attitudes to science. These will be discussed in relation to the values underpinning Bayside science culture identified above.

7.2.1 Predominately traditional view of science

Whether the prepared lessons, set in the physical sciences, influence the students positively or negatively is debatable. As the activities are hands-on and students have expressed a preference for hands-on activities there is potential for the lessons to influence attitude to science positively. However, In the Science Curiosity Inventory conducted for this study, the factor means produced for wanting to find out more about physical science were ambivalent at 2.08. This is only slightly over the mid-way point of 'not sure'. The form two students' general attitude to science was significantly less positive than students in form one and the physical science area showed this significantly too. Two items which can be directly related to the prepared lessons, is wanting to find out more about 'light' and 'what makes a rainbow appear'. On both of these items form two students scored as significantly less positive than their form one counterparts. These two items feature as central components in the prepared 'Radiant Energy' laboratory lessons, completed by all form two classes before the administration of the questionnaire. Either form two students feel that as they have already learnt about these topics, there is little else for them to learn , consequently they are less interested than the form one students, or alternatively, they are not interested because they did not enjoy it the first time. However, there are two limitations to this interpretation. Attitudes to science drop between form one and two anyway, as supported by this study and literature outlined in the literature review and this could explain some of this attitude drop to the physical sciences in form two. In addition, this is not a longitudinal study but a cross sectional one in which the form one and two groups are different groups of students with different histories. A more well-founded conclusion could be made on this phenomenon from a longitudinal study where a form one group were followed for two years, through form one and into form two.

Potentially the influence the prepared lessons in the physical science area could impact on student's science fair topic choice. Having some background exposure to physical science concepts and equipment is aimed to prepare students for the science fair and it appears to have resulted to an even spread of exhibits in categories. When science fair categories (Table 4.2) were grouped according to biological science (29% of entries), consumer science (29% of entries) and physical science (33%) there is not a large difference between these groups. 6.6% of students wrote that they wanted to learn more about chemistry and physical sciences in the open response section of the student survey and most of the form two students interviewed, discussed enjoying the prepared chemistry unit they were undertaking at the time. However, within the 113 entries in the 'physical science' area of the science fair, 37 were contributed by girls, and 76 by boys. Perhaps the prepared lessons are doing little to encourage girls into the physical science area.

An emergent theme from the teacher interview data was the perceived importance of teachers having content knowledge in the science subject area being taught. This is an area which the school science culture has the potential to influence positively. Teachers felt that when they had completed some background reading for themselves and had science content knowledge, they had the ability to answer students' questions, they had control and were able to imbue enthusiasm for science. For their part, students reported feeling positive when the teacher let them find out things for themselves, but also felt good when they understood things, when teacher showed their knowledge and explained 'why'. Teachers who did not inspire confidence were described as reading things directly off a sheet. Letting students find out things for themselves requires knowledge and practice in current constructivist teaching methods, which many of these teachers are unfamiliar with and which the leadership of science in the school does not model in the support material provided. Therefore, this potential link between school science culture and teacher and student attitudes could be strengthened by, providing more time for teacher preparation in order to gain content knowledge and providing teacher support which reeducates in current science teaching practice.

7.2.2 Strong leadership

The strong leadership or ownership of science in the school, taken by the Teacher with Responsibility for Science is appreciated by the staff. There is clear appreciation of the effort involved in providing the support given, even if they disagree with the approach taken. Even though, out of four contextual strands taught twice each during the two years students are at Bayside school, there are only three 'prepared units', there was much reference to them in the interview. The prepared lessons help many teachers feel positive and more confident in their science teaching. However, these lessons also produce conflict within some teachers, realising the their approach adopted in these lessons is not the one supported in the curriculum, but still using them. The students interviewed stated that they enjoyed 'hands-on' activities generally in science, and 25 students commented in the surveys that they wanted more hands-on , exciting activities. The 'closed' nature of the activities in the lessons could have a negative effect of students attitudes to science as many articulated in the interviews a keenness to find out things for themselves, not be told. Therefore, this strong leadership generates both positive and negative attitudes to science.

7.2.3 Outside schemes and competition

The involvement of outside schemes such as science fair and science badges, mould scientific investigation into manageable 'packages'. Science fair in particular is viewed as a competitive arena where able students are selected for extension programmes, with the aim of winning prizes. This has enhanced the school's image in the past. Over half of the teachers felt negative about the large amount of parental involvement in the science fair observed and one third about the competitive ethos of the event. In the open response section of the student questionnaire eight students spoke positively about science fair and nine, negatively. It is possible that it may be perceived by the students as elitist and this may depress positive attitudes towards it. However, all students interviewed in the focus groups who mentioned science fair spoke of it positively. In regard to the science badge scheme, although some positive elements were articulated teachers were concerned over the compulsory nature of them and the monitoring of their completion. In the student interviews over half of those interviewed discussed science badges positively and in relation to science completed at home. Therefore this scheme has potential to enhance students' positive attitudes to science.

Participation in the science fair and science badges is greatly aided by strong community and parental support. It is possibly through parental and community support that Bayside is able to make science fairs and badges a compulsory element of the school science scheme. This parental involvement evident as a key part of the organisational culture of science in the school, has been discussed as perceived negatively by teachers. However, students spoke positively of their parents' support when undertaking science activities at home. It is the parents who, to a large degree, help their children manage their time, find resources and information, gain access to display materials and computers to complete these projects to a high standard. Finally, there is possibly an unarticulated sense in which the parents send the message that these science tasks are 'important and valuable learning'.

7.3 Summary

There is a paradox inherent in the fact that Bayside science culture vigorously promotes science 'success' but students' attitudes to science generally are no better than their counterparts in Smail and Kelly's study, over 10 years ago. On an even more pessimistic note, the girls in this study like science less than Smail and Kelly's girls. Whilst learning in an environment which provides science support to teachers and there is much public emphasis on science, attitudes to science still drop at Bayside between form one and two, as indicated in the literature, and the gender divisions for interest in science continue along traditional lines. Throughout this study students were reflective regarding the types of science they liked and what motivated them. It could be argued that incorporating hands-on activities and cognitive challenge as described by students, requires a different type of teaching and different support for teachers than what has been described at Bayside. Two models of the relationship between school science culture and attitudes to science will be outlined following discussion of the findings in relation to the literature.

Chapter Eight
Discussion

In this section the findings of this study will be discussed and interpreted with regard to the relevant research literature. Initially the intended curriculum will be discussed followed by factors which impact on the transformation of the intended curriculum into the implemented curriculum; the culture of the science in the school including teacher ability in and attitude to teaching science and how parents value education. This is followed by a discussion of the factors influencing how the implemented curriculum is transformed into the attained curriculum; the school science culture including teacher beliefs and parental values, what students like in science, their gender and ethnicity. A discussion of the concept of 'understanding' and its relationship to attitude follows. The thesis concludes with two models of the relationship between school science culture and attitude to science.

8.1 The Intended Curriculum

As previously argued the 1993 science curriculum has been influenced by constructivist theory. Students' preconceived ideas are valued, students are encouraged to challenge these ideas and with the teacher's help, come closer to scientifically accepted knowledge.

Constructivist thinking is sympathetic with the expressed needs of the Bayside students. These students wanted to find things out for themselves in a hands-on way in open-ended investigations. They did not want to be told what the outcomes would be by a teacher but they did want to be told 'why' things happened at an appropriate time by a teacher. This instruction sequence fits with Osborne's (1982) conception of constructivist science teaching when he noted the first step in constructivist teaching is the teacher's lesson preparation which should lead to the teacher's understanding of the relevant scientists' views and the children's views.

At Bayside school however, a number of factors militate against taking advantage of the match between the needs of the students and what the 1993 science curriculum has to offer. These militating factors will be discussed next.

8.2 Factors Influencing the Transformation of the Intended Curriculum into the Implemented Curriculum

The culture of school science will be discussed, as influencing the transformation of the intended curriculum into the implemented curriculum. This includes the attitudes of teachers, parental values and the size of the school.

8.2.1 Culture of school science

This study was modelled on a concept of culture outlined by Beare and Millikan (1989). While selected aspects of the conceptual, behavioural and visual manifestations of the school science culture at Bayside have been investigated and described they deserve some illumination with respect to the literature.

Two underpinning values of the school science culture at Bayside are strong leadership and a predominately traditional approach to science. In reviewing the history of intermediate school science curriculum and the Bayside prepared science lessons, the latter appear to have much in common with the 1967-1970 form 1-V science syllabus. Both reflect a teacher-directed orientation where emphasis is given to assimilation of factual knowledge. Both are also set out a step-by-step ‘cookbook’ manner. It is possible that the teacher with responsibility for science at Bayside used the teachers’ guides for this syllabus as a starting point when creating the prepared lessons. Whatever the reason, the resulting product does not reflect science teaching as the 1993 science curriculum intends. Therefore, the teacher with responsibility for science is a key factor in transforming the intended curriculum into the implemented curriculum of the school scheme.

Strong cultures are transmitted and embedded by a number of different mechanisms. How science culture is embedded and transmitted at Bayside can be illuminated by discussion of Schein’s (1992) concept of primary and secondary embedding mechanisms. Of Schein’s (1992) six primary embedding mechanisms, the teacher with responsibility for science at Bayside, embeds the school science culture using three of them.

Schein (1992) argues that what leaders pay attention to and control on a regular basis is what they will reinforce in the culture. The teacher with responsibility for science at Bayside pays daily attention to the science laboratory and to the science resources for the physical sciences, and on a weekly basis to the preparation of extension students to compete at science fairs as well as Monday lunchtime ‘help sessions’ for staff. Hence the values at the centre of the school culture of support in the physical science area and competition are reinforced. Schein also argues that “even casual remarks and questions are consistently geared to a certain extent and can be as potent as formal control mechanisms and measurements” (Pg 231). This is what Beare and Millikan (1989) refer to as ‘covert rules, rewards and sanctions’. During staff meetings the teacher with responsibility for science at times made general congratulatory remarks regarding use of the science room stating how good it is to see how full the science room booking sheet is, and congratulating those people. Comments like this could be interpreted as a covert message, sanctioning those who do conform to the prescribed plan.

The criteria by which scarce resources are allocated, is also seen by Schein (1992) as a primary method of embedding and transmitting culture. The teacher with responsibility for science allocates the science budget to the running of the laboratory programme and the science fair, and at the end of 1995 purchased some science education literature for the staff library. This indicates the central focus for the money is on the formalised parts of the programme.

The ways in which leaders role-model, teach or coach, is also seen by Schein (1992) as being a primary mechanism to transmit culture. The workshops run for teachers on how to teach the prepared lessons role model the ideas that preparation and some level of baseline subject knowledge are important. The format of the lessons also models a non-constructivist style of teaching. The coaching of science fair pupils on a one-to one basis in extension groups indicates the importance of helping the able to achieve at a top level.

Schein (1992) also posited secondary reinforcement mechanisms used by leaders to embed culture. These only work if they are consistent with the primary mechanisms suggested.

How the organisation is designed and structured is a secondary mechanism that can embed culture. It is argued that 'founders' often have strong theories about how to organise for maximum effectiveness and that the organisation's design is often built around the talents of an individual manager rather than the external task requirements. As the founder of the present way of science organisation in the school, the teacher with responsibility for science at Bayside has ensured science's 'survival' as an important feature of the school by structuring the organisation of science around his talents and structuring a major science event, the science fair, as central in the school's annual calendar. His organisational systems and procedures (another secondary articulator of culture), such as the prepared science lessons are based on certain assumptions about primary school teachers and science. Having a 'well oiled' system for major events such as the science fair ensures that not too much of the burden falls on one person. Classroom teachers and parents are supported by targeted help and the teacher with responsibility for science is aided in the administration of the science fair by the Deputy Principal.

The design of physical space and buildings is another secondary transmitter of culture. (Schein, 1992) The Bayside science room as a separate space for science teaching denotes the subject's importance. Its layout and contents, described earlier reflect the emphasis on physical sciences. Formal statements of organisational philosophy such as the school science scheme, already discussed, can also assist in the embedding of culture.

Rites and rituals are also argued by Schein (1992) as embedding culture. The behaviours ritualised through the science fair, science badges, BP Technology Challenge and the New South Wales science test become a reinforcer of the values of the importance of competition and emphasis on outside schemes underpinning school science culture.

A similar concept to the 'embedding' of culture is Mitchell and Willower's (1992) theory of reinforcing elements building an effective organisation. The sharing of expectations regarding science events such as science fair, between the students and teachers reinforces science as a worthwhile learning activity. The student group have internalised teacher expectations regarding participation in this event and this is further reinforced by parental expectations and support.

An analysis from Bates' (1987) point of view, however, would argue that what is being reproduced during an event such as Bayside's science fair is 'high culture' in that the administration is judged as successful if it is able to inculcate the culture of science fair successfully to the participants.

(i) Teacher beliefs and practices

Situated within the culture of science in the school, are the attitudes of teachers towards science. The generally positive attitude towards science exhibited as a group, by the staff of Bayside school contrasts with the generally negative attitudes of primary teachers to science and is perhaps surprising considering their collectively low level of prior science experience and training. They stated that they found the support received from the prepared laboratory lessons and from the teacher with responsibility for science to be helpful and this could explain their positive attitudes. It could also be a flow-on effect from being part of a school which has public success in science. The teachers' prior level of science content and teaching knowledge also has influenced the transformation of the intended to the implemented curriculum, as the teacher with responsibility for science has adopted systems to try to compensate for low levels of science knowledge among the teachers.

The teaching staff are under the influence of the culture of the school. The science support they receive does not role-model approaches consistent with the 1993 science curriculum, therefore they have no lead to follow. When performing their role of transforming the intended curriculum to the implemented curriculum, their lack of science content knowledge and lack of preparation time means they acquiesce in the implementation proposed in the 1993 curriculum. Tobin et al. (1990) found in their in depth case study of two high school science teachers that the teachers were not 'free agents' "rather each worked within the sociology of the school and its community. In addition we realised that Peter, and to a lesser extent, Sandra were not change agents. They accepted and reproduced some of the mores of the community and school rather than trying to transform them. Both accepted and used curriculum which had shortcomings" (Pg 23). This is similar to the Bayside teachers who, while critical of the style of the prepared science units, continued to use them in preference to preparing their own.

Lack of teacher knowledge was a theme which emerged in the interviews with teachers and has been seen to influence investigative opportunities and deeper understanding of science. The paucity of opportunity for students to develop their own investigations can be linked to this lack of science content knowledge. Roth and Roychoudhury (1993) argue that open-ended investigation work "entails an underlying intellectual expectation from the teacher" (Pg 148). One could speculate that a lack of background knowledge has made the investigation phase threatening for Bayside staff. This would be unfortunate as participation in open-ended investigation has been found to have a strong predictive value on science persistence in later years (Gallagher, 1994). Harlen (1989) also argues that science education where ownership of ideas is promoted, is more likely to provide equal opportunities for both sexes than a traditional 'transmission' approach. In addition, student-centred investigation in science is a central part of the 1993 science curriculum which New Zealand teachers are required to teach. Tobin et al. (1990) argue that discipline specific pedagogical knowledge about content and pedagogical knowledge about controlling the class is helpful if the students are to attain higher level cognitive outcomes in science. These higher levels of understanding are important because as Bayside students articulated, when students understand science they also enjoy it and have a positive attitude towards it.

Jean and Farnsworth (1992) in Australia stated that teachers felt 'kits' would be helpful with sample learning experiences to overcome the problem of lack of teacher knowledge. However, the majority of the support that Bayside staff receive in teaching science is in the form of 'kits'. Whilst 'hands-on', their contexts are not consistently child-centred and the emphasis is on following instructions to find the prescribed result. In not reflecting the current curriculum, Bayside's kits make no attempt to educate or reeducate staff to current teaching practices and reinforce traditional, teacher-centred practices. In their analysis of textbooks and activity guides as a means of promoting open-inquiry teaching, Pizzini et al. (1991) conclude that ultimately the responsibility rests with the science teacher as the 'pre-prepared' materials which they reviewed were not designed to facilitate open-inquiry teaching.

It appears that, Bayside teachers are not alone amongst teachers in New Zealand in utilising science materials prepared by other teachers or science specialists in the school. The New Zealand TIMSS data (Garden, 1996) shows that of teachers of form two students surveyed, 71% use their own previously prepared units at least 'sometimes' and 71% use plans prepared by other teachers/science specialists at school at least 'sometimes'. In comparison, of the teachers of third form students surveyed who more than likely have science degrees, 88% use their own prepared lessons at least sometimes, and 53% at least sometimes use plans written by teachers/science specialists at school. It is likely that the greater use of pre-prepared materials by intermediate school teachers is related to their weaker science knowledge.

In addition to lack of subject content knowledge and training in current teaching techniques, it is possible that teachers want to use what current teaching pedagogy knowledge they have, but find themselves stifled by pragmatic issues such as lack of time and resources. Sykes (1988), argues that inspired teaching is the missing element in the 'effective schools' movement and that teachers develop coping strategies in the face of their difficulties: "The first and continuing imperative of teaching is to establish and maintain an orderly classroom - to set up rules and routines that support predictable patterns of behaviour. Only within an orderly environment can teaching proceed. The enemy is disruption, and the precious resource is time. Teachers seize on methods that increase their efficiency in managing students in large groups" (Pg 462).

The Bayside prepared units were devised as such a method of managing students in large groups. While it is whole class instruction with little or no individualisation, Tobin et al. (1990) found in a classroom with a high level of small group and self-paced work that disruptive students and management difficulties greatly lessened learning opportunities. They concluded that stopping whole-class teaching in favour of small group and individual approaches was not necessarily a cure-all. Many teachers at Bayside discussed lack of preparation time as a practical issue which stifled science teaching, a sentiment also echoed in the literature; Fernandez (1994) Bryd and Doherty (1993).

(ii) Parental values

Parental values influence what is included in the implemented curriculum. Bayside school could not sustain programmes such as the science fair and science badge scheme, which require both cognitive and monetary support from parents, if parents did not support it. Goldring (1986) suggests that communities such as Bayside's which are assertive in their demands of the school can create uncertainty for the principal. One way she posits of overcoming this is to actively engage the parents in the programme "in order to co-opt and socialise them and ultimately absorb the uncertainty" (Pg 119). It is also likely that as parents of high socio-economic status, they would be supportive of the New Right elements of competition and individualisation (Lauder, 1990), and therefore also supportive of the implemented curriculum focus at Bayside.

(iii) Size and type of school.

Bayside School with a roll of 593 students is a large Intermediate school. As a large school there may be some intrinsic factors impacting on attitude to science. The National Education Monitoring Project investigation of science (Crooks & Flockton, 1995) found, in respect of form two students that enthusiasm for science decreased with the size of the school and that intermediate school students were less enthusiastic about science when compared to their full primary school counterparts. However, they did not give any reasons why this may be so. Further investigations of intermediate and full primary schools of various sizes and interviews with their students and staff may identify factors contributing to these trends. Therefore, coming from a large school, Bayside students' attitudes towards science may be depressed, if compared to students who may have attended smaller schools.

8.3 Factors Influencing the Transformation of the Implemented Curriculum into the Attained Curriculum

The attained curriculum, in this case, consists of the attitudes towards science that students have acquired during their schooling. Factors affecting the development of the attained curriculum will be discussed. The school science culture factors include teacher beliefs and practices, parental attitudes and science rituals and artifacts. Student level factors include what students like, gender, ethnicity and understanding.

8.3.1 Culture of school science

While the teacher with responsibility for science and the teachers' low level of science content knowledge influenced the transformation of the intended into the implemented curriculum, these same factors also influence the attitudes which students attain.

(i) Teacher beliefs and practices

The implemented curriculum (the school scheme) influences teacher beliefs and practices, which impact on student attitude. This is supported by Keeves (1992), who argues that school science support influences teacher views of science teaching and therefore student attitudes.

The Bayside teachers' generally positive attitudes to science have the potential to influence the student attitudes positively. However, in the teaching practices adopted, opportunities to enhance student attitude to science are not being taken as often as they could. Students were very enthusiastic about conducting their own investigations but there appeared little opportunity for students to regularly develop their own investigations in a familiar context. Perhaps, however, it is not surprising that appropriate practices, as outlined in the science curriculum, are not in place. Biddulph and Carr (1992) have argued that, in respect to preservice teachers two science courses of 36 hours each are necessary for teachers to change their views about children's learning in science. As indicated by Table 5.4, it is doubtful whether any of the Bayside school staff, perhaps with the exception of the two 'frequent course attenders' would have received instruction approximating this quantity.

The "teacher mind-frame" (Tobin, 1990) comprised of the beliefs of teachers, content knowledge to be taught and knowledge of how to teach science content, influences how learning situations are structured. The 'mind-frame' of Bayside teachers with regard to science, influenced by the school science scheme and culture, does not match as well as it could with the expressed needs of the students for investigative opportunities in science lessons.

(ii) Parental values

In this study parental values are viewed as an integral part of the school science culture, with potential to influence student attitude to science.

While the opportunity to pursue their own investigations in the context of class lessons, may not happen in every unit taught, Bayside School's involvement in the science fair scheme, does provide investigative opportunities in a different guise.

As previously discussed, parental involvement and support is instrumental in this event as also seen in other studies (Tytler, 1992). Nash's analysis, based on his 1993 study of family resources in New Zealand would be that Bayside families are passing their cultural capital onto their children. This is true of Bayside families in terms of material support with science boards, equipment and computers at home. The intellectual resource at home is also a key factor in guiding science fair studies together with the attitudes imbued that this task is worth pursuing. Solomon (1994), would argue that these middle class children do not necessarily have an educational advantage, but that the home culture has imprinted its own messages regarding values relating to education. However, as Bayside children will operate in an educational system catering for the dominant culture (Bates, 1987) the value messages received at home regarding the importance of education will fit them well for success.

(iii) Science rituals and artifacts

In addition to the contribution of teachers and parents to school science culture, students also experience the science rituals and artifacts. As previously argued the artifacts of school science, such as the school scheme influence teacher practice and student attitude; the prepared science lessons effect the attained attitude of some students. The rituals of science fair and science badges also evoke both positive and negative attitudes. Woolnough (1994) has argued that the pursuit of these extra science activities can predict future science uptake.

8.3.2 Student factors

Factors present in the student's personal background interact with those present in the culture of school science. Where there is similarity between what the school science culture offers and what students want, one could argue that the attained curriculum of attitude to science could be optimised.

(i) What students like in science

Bayside students expressed a keen desire for more hands-on activities and also for open-ended activities. Open-ended activities are where a step-by step- method is not given for the solution of the problem. This mirrors the desires of students of similar ages in other studies such as those by Wasserstein (1995) and Baker (1992). From their responses, Bayside students would endorse the Model of Intrinsic Interest posited by Martinez and Haertel (1991). They wanted science activities which were cognitively challenging, where the expected answer was not told to them in advance. They also wanted manipulation of hands-on equipment. If possible this should incorporate a social element and so be undertaken with others. These are the three components of the Model of Intrinsic Interest. Jarman (1993) suggests that students of intermediate school age perceive the use of equipment in science as more grown-up stating "In the mind of the child, it seems, the lighting of a bunsen burner assumes the rite of passage into the realm of 'real' science" (Pg 23). Bayside students also stated they liked science when they understood it. This is another factor which impacts on the attained curriculum of attitudes and will be further examined in section (iv).

(ii) Gender

A number of stereotypical gender differences emerged in the Bayside data which support the science education literature in the area (Taber, 1992). Girls showed more enthusiasm for human biology and nature study than the boys. The boys reported more enthusiasm for physical science. There was no significant difference between these results and those for English students a decade earlier (Smail and Kelly, 1984). Boys scored higher on items pertaining to a general liking for science but were less positive than the girls in their perception of science as a force for good in the world. Boys also tended to perceive science as masculine construct more strongly than the girls. The fact that the Bayside girls like science significantly less than Smail and Kelly's students is a cause for concern, although the English students were experiencing more science than their Bayside counterparts and the science emphasised at Bayside was largely physical science, which is not popular with females. However, on a more positive note, the Bayside boys see science as less of a masculine pursuit than Smail and Kelly's male students.

When Kelly (1986) readministered the same questionnaires to pupils two and a half years after the original data were collected and after some schools had implemented interventions to improve girls' attitudes to science, she saw little evidence that interventions had had effect in terms of girls having more positive attitudes to science. Kelly (1986) found that:

"Sex difference stayed much the same between the first and second testings. They were highly significant on all eight scales, with girls scoring better than boys on NATSCUR, HUMBICUR, SCIWORLD, SCIENT and SCIMALE and boys showing more favourable attitudes than girls on PHYSCUR, TVSCI and LIKESCI. On both occasions there were large sex differences on PHYSCUR and SCIMALE, but only small differences on TVSCI and SCIENT." (Pg 405).

The 'action schools' which implemented affirmative action policies to improve girls' attitudes to science did better over all than the control schools, but the differences were slight. They were seen most clearly in 'science is male' factor but were also evident in the 'physical science' factor, the 'liking of science' factor and the 'image of scientists' factor where the attitudes did not drop as sharply as in other schools. Kelly (1986) concludes that schools can and do have an effect in promotion of positive attitude to science, and that detailed case-study work is necessary to identify the central factors which produce these effects in order to reproduce them in other schools.

Research regarding female self-image and attitude towards science by Staberg (1994) Smail and Kelly (1984) and Kelly (1988) illuminates some of the outcomes of the Bayside study. Kelly (1988) found that girls who saw themselves are feminine were more likely to see science as suitable for boys rather than girls. This is interesting in light of the Bayside focus group interviews where, although the two groups of form two girls (aged twelve and thirteen) expressed positive attitudes about doing experiments and hands-on activities, they expressed dislike of activities they termed 'engineering'. One girl explained herself by saying "you are not really experimenting ... you're just making things ... it's just technical" (Form Two girl). It could be that she perceives this hands-on manipulation a masculine domain that does not fit with her self-image. Also, she may have lacked 'tinkering' experience as a child and therefore felt insecure with such learning activities.

Staberg's (1994) suggestion that "Femininity was constructed as associated with maturity" (Pg 39) illuminates comments made by the other group of form two girls, who when talking about how they disliked using lego, said that it was alright for students of standard two age, but not for people of their age. It appears that theirs is a construction of what it is it be an adolescent female.

(iii) Ethnicity

At Bayside school the students of Asian origin reported liking science significantly more than the students of European origin. This parallels other data collected in New Zealand recently. In the national results from the Third International Maths and Science Study (Garden 1996) form two and three Asian students combined was the group with the largest proportion reporting that they enjoyed doing science (81%). The third form Asian boys were most likely to 'strongly agree' that they enjoy doing science (39%). In addition Asian students were the largest group who would like to have a job involving science (50%).
It is possible that the Asian students are influenced by values from their families and countries of origin. When investigating the impact of ethnicity on math and science among gifted students, Campbell and Connolly (1984) found that Asian

students devoted much more time to studying and research activities, with their families being very supportive of this. They concluded that Asian students tended to retain the attitudes and values of their home countries and were more competitive than Caucasian students.

(iv) Understanding

It became apparent that understanding was located closely to enjoyment of science. Steinkamp and Maehr (1983) suggest that "the liking of science is an outcome that is derived in large measure from having actualised one's potential in this regard - and done well" (Pg 388). It could be argued that actualising ones potential is similar to understanding. Bayside students presented a number of different meanings for 'understanding'. These were deduced when the students were invited to share something they understood in science and explain how they knew they understood it.

A study by Helmstad and Marton (1992) examined conceptions of understanding held by people ages 12 to 75 years. The events described by their participants were classified in three main categories: acquiring a desired skill, getting to know something and understanding something. Helmstad and Marton (1992) argue that only the final category, 'understanding something', (which they subsequently break down to eight subcategories,) is indicative of real understanding. They argued that the first two categories actually refer to learning, not understanding. Using the data from the various ages represented they conclude that "the idea of understanding seems to be developmentally differentiated from the idea of learning, that more than half of the episodes described by the 12 year olds reflect lack of differentiation and that the clearly most frequent form of conceptualising understanding in all other groups presents an "existential character" (Pg 16).

Burns, Clift and Duncan (1991) identified two orientations towards understanding which formed opposite ends of a continuum. A coherence orientation referred to students who were trying to find order within the subject matter. A knowledge orientation was indicated by the ability to recall factual information. These orientations were also linked with ways in which students assessed their own understanding. A coherence orientation was matched with intrinsic assessment and a knowledge understanding with extrinsic assessment. Every focus group interviewed at Bayside said they knew they understood when they had done something, experimented or made something.

Burns et al. (1991) categorise 'knowing how' as knowledge-orientated. It may be assessed intrinsically as well as extrinsically. The three focus groups of girls who claimed to recognise understanding on the basis that the teacher, book or worksheet had told them were displaying an extrinsic orientation to assessment, where knowledge was likely to be the focus. Burns et al. found that "higher achieving students tended to use a coherence orientation towards understanding either solely or in conjunction with a knowledge orientation, more often than did low achievers" (Pg 284). And that girls more than boys were more likely to be coherence orientated. This is supported by Staberg (1994) who found girls more likely to make connections between ideas and to be concerned with understanding. The form two girls who had been in science extension for two years running displayed high levels of coherence and intrinsic assessment of understanding. They discussed explaining their projects to other people and being able to 'do anything' with the information they learnt. This evidence for real understanding is supported by Entwistle and Entwistle's (1992) findings where university students claimed that understanding gave them confidence in explaining to others and flexibility in applying ideas. However, when considered as one group, the girls in various focus-groups used extrinsic measures more than the boys, even high achieving and coherence orientated girls, because of a lack of confidence.

Therefore Bayside students demonstrated all three of Helmstad and Marton's (1992) levels of understanding.

When students at Bayside were asked how they knew when they didn't understand, there was much reference to extrinsic assessment and knowledge, with comments focusing on not being able to answer questions or participate in an activity.

Groups interviewed at Bayside gave positive responses when asked how they felt when they understood, for example: "it feels good", "you feel pleased with yourself "and "I feel happy that I know how to do it". Burns et al. found similarly with their cohort of sixth form chemistry students. Less than half of the chemistry students would ask a teacher for help, instead choosing to ask other students or pretending to understand. The same was the case with the Bayside students. Both sets of students did not want to be criticised by the teacher for not listening.

Burns et al. (1991) argue for three initiatives in senior science learning environments in order to promote coherence understanding, however, similar could be argued for schools at all levels. They posit that students should be taught about understanding, they should be taught the skills to achieve coherence. Finally they argue for a learning environment where time is allocated for independent study, student-teacher discussion and student-student discussion. They finally suggest "fewer topics and topics which respond to student interests and concerns, since the achievement of coherence requires active involvement and effort and therefore high motivation" (Pg. 286). This is interesting in light of the Bayside students who want relevant topics, and want to be actively involved. One has the feeling that while attitude towards science is reasonably positive at Bayside school, there is a pool of untapped potential energy in terms of students who want to be active in science and want to understand - if this potential was maximised by the school science culture.

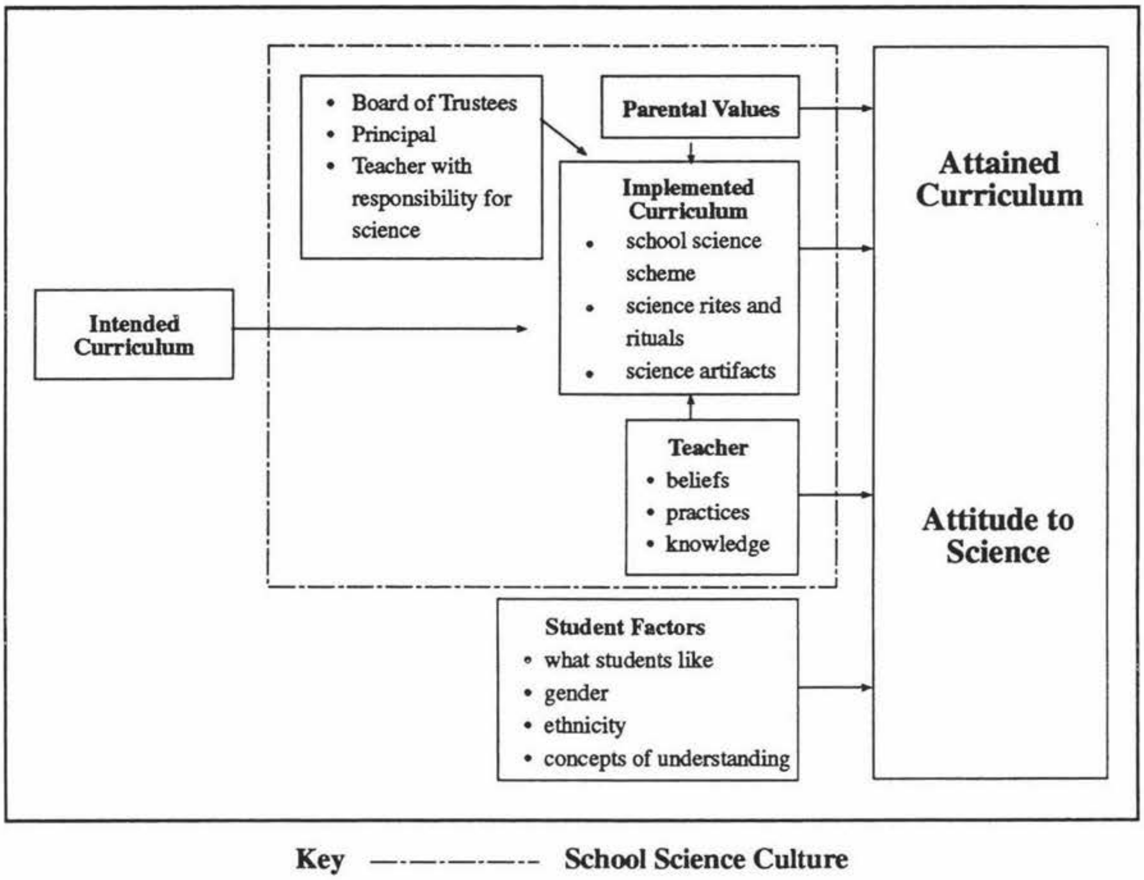
8.4 Developing a Model of the Relationship Between School Science Culture and Attitude

The model presented in figure 8.1 represents the relationships between intended, implemented and attained curriculum and school science culture. The intended curriculum, Science in the New Zealand Curriculum (1993), has some influence on the implemented curriculum or school scheme. The circular broken line, represents school science culture. It is comprised of the principal, the teacher with responsibility for science, teacher content knowledge, teacher beliefs and practices, parent values and science rituals and artifacts. The teacher with responsibility for science interprets and transforms the intended curriculum into the implemented curriculum. In the case of Bayside school the person in this position is influenced by his beliefs and perceptions regarding the teachers' low level of science content knowledge and the most efficacious way of compensating for this. The principal's beliefs and attitudes can also be influential. At Bayside the principal supports the parts of the scheme which emphasise the science badges and science fair. The implemented curriculum at Bayside can only function with the input of parents, so their influence is also denoted. Therefore there are four channels of influence transforming the intended to the implemented curriculum.

As well as influencing the development of the scheme, teacher beliefs and practices also play a major role in transforming the implemented curriculum to the attained curriculum of student attitude. Together with parental values, science artifacts and rituals, teacher practices interact with the students' personal background of gender, ethnicity, what they like in science and their orientation to understanding to result in the attained curriculum of student attitude to science.

Figure 8.1

The relationship between school science culture and attitudes to science - a curriculum view.



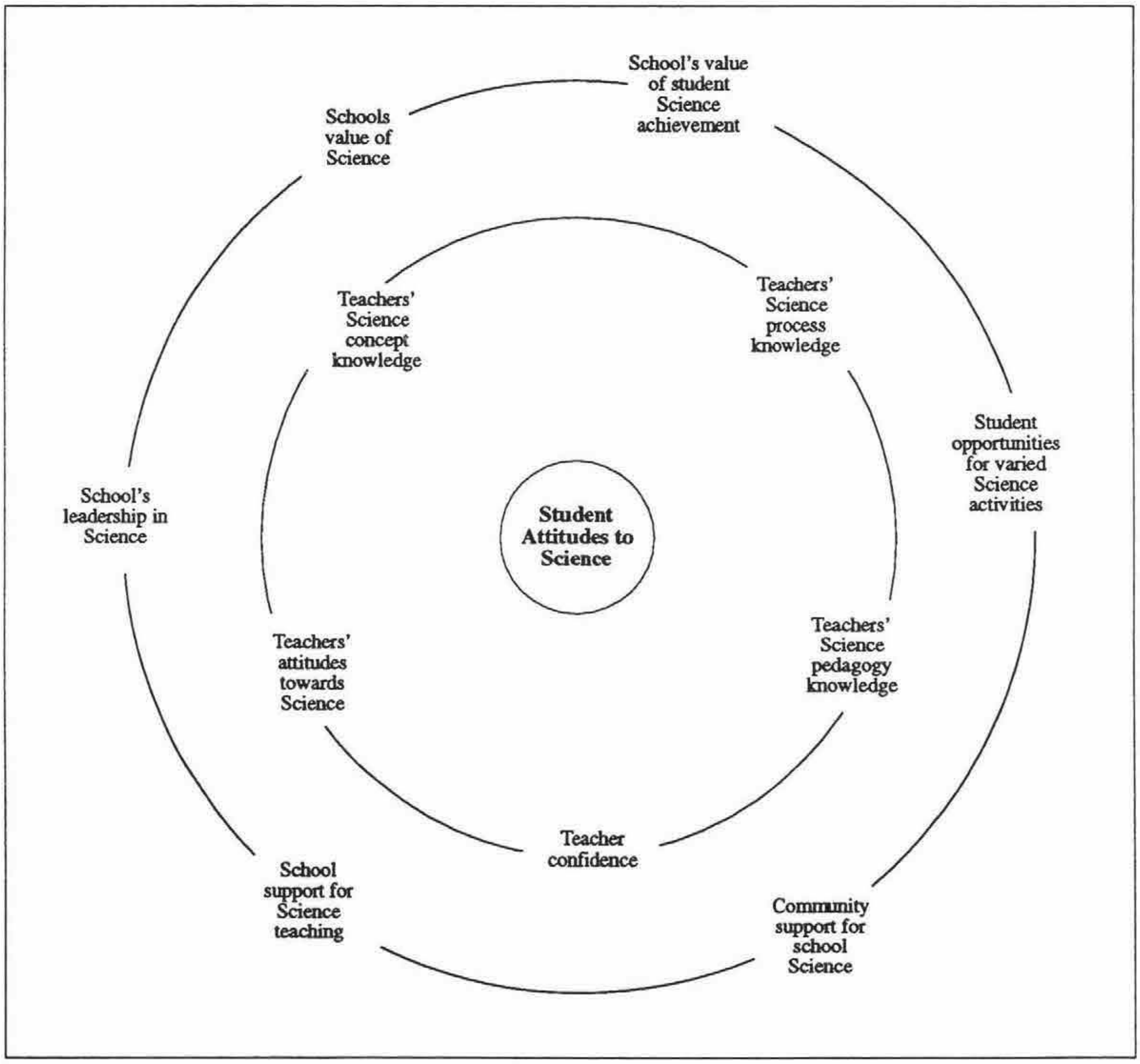
One could argue that the more optimal the match between the school culture of science and student factors, the greater the opportunity for positive attitude to science.
In the case of Bayside, the opportunity for positive attitude could be enhanced if the teachers were supported in a manner more consistent with the intended curriculum, both in terms of content knowledge and teaching approach and had more time to prepare hands-on, challenging, open-ended science lessons. Then students would be cognitively satisfied as they could find out for themselves, affectively satisfied because activities would be fun and understanding makes one feel good, and behaviourally satisfied through completing hands-on activities.

A complementary model to the one posited above uses Charron's (1991a) suggestion of 'nested systems' in science to illustrate the way in which teacher attitudes to and confidence in teaching science and knowledge of scientific concepts, process skills and science pedagogy, mediate between the school science culture and the attitudes to science which the students develop.

The outer circle represents the school science culture, encompassing the school's value of science, school science leadership, the support for science teaching, the community support for science, the school's value of student science achievement and student opportunities for varied science activities. 'Nested' within the school science culture are aspects of teacher confidence to teach and knowledge about science teaching. The school science culture has the potential to influence this positively. In the inner circle, student attitudes to science are represented. These are argued to be influenced by the levels represented around it.

Figure 8.2

The relationship between school science culture and attitudes to science - a nested system.



While this model presents a holistic picture of the relationships articulated in this study between culture and attitude, Chapter nine presents a summary of the answers to specific questions guiding this study.

Chapter Nine

Summary of Answers to Research Questions

As this is a single site case study, it is only possible to draw general conclusions from the internal relationships and characteristics of school culture within Bayside school. However it has described, in detail, how one school values science, how it organises science delivery, chooses to support its teachers in teaching science, and interacts with the community. In the course of this description, views of management, teachers and students have been articulated to identify interconnections between the culture of science in the school and teachers' and pupils' attitudes to the subject.

9.1 Answers to Research Questions

A summarised answer will be provided to each research question.

9.1.1 Question One: What are the attitudes of intermediate school students towards science in the school examined?

(i) What is the nature of the students' attitudes to science?

The students were curious about science. They were most curious about science which, appears on television and science relating to their own bodies. As a population they liked science, had a positive image of science in the world and a positive image of scientists. Students liked open-ended, hands-on activities which they described as fun, interesting and exciting. These type of activities appear to be challenging. In contrast activities deemed as 'boring' have no challenge. Understanding science is also seen as enjoyable.

(ii) How do students' attitudes to science interact with school level (form one and two) and gender?

Form one students are more curious about science, particularly about nature science than the form two students. Form one students like science significantly more and have a more positive image of science in the world and scientists than their form two counterparts. There were large differences between boys and girls with boys being more curious about physical science and girls more curious about human biology and nature science. Boys liked science more than girls, had a less positive image of science in the world and agreed more than girls that science is a male pursuit. Ethnicity was not an area originally targeted for comparison in this study, but there were enough students of Asian origin to make this possible. Asian students were much more curious about science than European students and than the population as a whole. They also liked science much more than the European students.

9.1.2 Question Two: What is the culture of science in the school examined?

(i) What are the underpinning values of school science culture?

The underpinning values of school science culture were found to be: a predominately traditional view of the nature of science, strong leadership, emphasis on outside schemes, and competition.

(ii) What is the nature of teachers' attitudes to science and its teaching?

Most of the teachers had a positive attitude to teaching science. Many of them said they felt well supported by the teacher with responsibility for science, although some questioned his approach. However, many also said that they would feel more confident in their science teaching if they had more content knowledge and felt this related to pupil enthusiasm for the subject. Some teachers demonstrated a positivist view of science. The teacher with responsibility for science demonstrated a positive attitude to science teaching as developing students enthusiasm and a positive attitude to science as a positivist pursuit. The management of the school support the emphasis on outside schemes and competition, while the technicraft staff infuse some science knowledge through their subjects.

According to their own self-reflections, it is questionable whether classroom teaching staff are using students' ideas as a basis for learning or facilitating investigations as often as would be optimal to fulfil the thrust in the 1993 science curriculum document towards investigations in science and the emphasis on constructivist theories of teaching.

(iii) How is science represented in the school curriculum documents?

In Science in the New Zealand Curriculum (1993) science is represented with an underpinning of constructivism, where science is for all and students should be active in constructing meaning for themselves, in familiar contexts. When Bayside interpreted the curriculum to write the school science scheme, they imbued their own emphases and introduced their own ideas.

(iv) What form does school science take?

School science at Bayside school takes the form of class lessons, some of which are planned and resourced by the teacher with responsibility for science. These lessons feature sheets where students work through hands-on experiments step by step in contexts that are not child-centred. The answers tend to be given on the sheet. The school also emphasises a science badge scheme where students complete science activities to earn a badge and school science fair where participation is compulsory for form two students. The school also enters students in the BP Technology Challenge and the New South Wales science tests. The school has had a high level of success in the regional science fair in past years, has built a reputation for this, and prepares selected students in extension groups to this end. There is strong parental and community interaction around the science fair and science badges.

(v) What are the resources and symbolic elements of the school science culture?

The designated science teaching space, with furniture formally arranged and the predominance of secondary school-type equipment used to teach physical sciences point to a traditional view of science. The sleeve badges are symbolic of participation in science activity and being sought after, are indicative of the value of competition underpinning school science culture.

9.1.3 Question Three: How does the organisational culture of science in the school relate to the students' and teachers' attitudes to science?

While it would be impossible to speculate any specific causal relationships between variables, some probable relationships have been illuminated:

- There is a relationship between the underpinning value of science support and the teaching of the material and physical world units. Ultimately, as a result of the support, teachers can't avoid teaching these areas. In areas where teachers have low levels of confidence and subject knowledge, they tend to employ strategies to avoid teaching science (Harlen and Holroyd, 1997), but this is not possible at Bayside because of the support structures in place. Therefore the students are exposed to the full range of science areas.

- More positively, as a result of the science support, teachers feel more confident in these areas of science and spoke about being better able to control the class, answer questions and imbue enthusiasm as a result of this support. The students discussed their positive attitudes when teachers had some background knowledge and could explain 'why'.

- However, there was a negative link, for some students between the science support offered and positive attitudes to science as some felt that the prepared lessons were too teacher directed and not open ended enough.

- Linked to this, the paucity of opportunity to pursue investigations of their own choosing during science lessons meant that the opportunity to build positive attitude is not optimised.

- Other specific aspects of the Bayside science culture also elicit positive and negative attitudes for teachers and staff. Some students and staff questioned the selecting off of able students for science extension. Some teachers felt negative about the competitive element in the school science culture and the level of parental involvement in science at Bayside.

9.2 Future Research

This study raises a number of complimentary research questions. In a less supportive or assertive community, would the students show a similar level of interest in science and would it be possible to make activities such as Science Fair and Science Badges compulsory? In other schools would one find a similar proportion of teachers adopting the approaches advocated in the 1993 science curriculum? What would the Bayside students attitudes to science be without the prepared laboratory lessons? With appropriate in service training, would the provision of more preparation time encourage teachers to take more responsibility for their own science teaching in the school instead of reliance on 'packaged' resources? Further in depth description of methods employed by other schools for organising and supporting science is required, together with measures of their students and teachers attitudes, to ascertain the efficacy of alternative ways of supporting teachers to deliver science teaching which will build positive attitudes to the subject.

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Appendix One
Bayside School Documents

Contents

19 April 1995

NEWSLETTER NO 6

Science Fair

has spoken with all Form Two classes and outlined requirements for the preparation of Science Fair projects. Members of the Science Curriculum team will make this information available to parents tonight.

The development of a research study and presentation of the data in the Science Fair is one of the major tasks for Form Two pupils. In order to succeed they need to select and stick to a topic, plan their time allocation over five to six weeks, collect data and develop a display. This requires time and resource management as well as ideas. Form Two pupils have priority access to the school computers in the lead up to Science Fair. These can be used after school as well as in class time. This is a good opportunity to show computer skills as well as ability to apply scientific method.

During the period of project preparation teachers will monitor and check off the progress sheet. Do discuss your child's study with them. If you experience problems contact the class teacher or

15 June 1995

NEWSLETTER NO 9

Science

Students who are preparing Science Fair exhibits are keeping our computers working very hard. The computer room is available beyond school hours and on Saturday mornings for this purpose. As well the Science Room will be open on the next two Saturday mornings so that pupils who need to consult with have a chance to do so.

Some very interesting projects are taking shape. Do allow time in your diary to visit the Science Fair 27 - 29 June, bring friends and grandparents.

Form Two Prepared Unit - Material World.
Chemistry

Lesson Number	Topic	Activity Type	Opportunity given for own investigation	Use of hand-on equipment	Application of knowledge to child's world	Analogy used	Clean up instructions given	Safety instructions given	Key Vocab.	Recording instructions given.	Equipment used.	Teacher Demon- -stration
One	Mixtures	Activity One: "Separating colours" * Learning outcome is stated. Step by step method given for activity.	No	Yes	Equipment used is from a child's context. -felt pens	No	No	No	Separation	No	Chromotography Paper Felt pens Methylated spirits	No
		Activity Two: "Dissolving and diffusing" * Learningoutcome stated. * Step by step method given for the activity.	No	Yes	As above	No	No	No	Separation Particles Chromotography Different speeds Different properties	Yes	As above and: Solvent Test tubes.	No
Two	Dissolving and Chemical Change.	Experiment One: * No problem or aim * Step by step instructions * Discuss what might be happening	No	Yes	Discussion of chemical change and cake baking	Yes	Yes	Yes	Chemical change	No	Sodium Thiosulphate Copper sulphate Test tubes Meths burners	Yes at end.
		Experiment Two: * No problem or aim * Step by step instructions * Discuss what might be happening.	No	Yes	No	No	Yes	Yes	As above	No	As above	
		Experiment Three: * No aim * Step by step instructions. *Followed by one page of "notes for teachers'."	No	Yes	No	No	Yes	Yes	As above	No	As above	
Three	Refresh your Memory	"During the last lesson you should have come to the following conclusions".	No	No	Questionable	No	No	No	Solute Solvent	No	-	No

Form Two Prepared Unit - Material World.
Chemistry (continued)

Lesson Number	Topic	Activity Type	Opportunity given for own investigation	Use of hand-on equipment	Application of knowledge to child's world	Analogy used	Clean up instructions given	Safety instructions given	Key Vocab.	Recording instructions given.	Equipment used.	Teacher Demon--stration
Four	Separation by flotation and evaporation	* Problem stated * Step by step instructions on how to do the experiment including exact measurements: "No more or your experiment will take too long to complete". * Discuss outcomes with teacher at the end.	No	Yes	Salt and sawdust?	Yes	Yes	Yes X2	Evaporation	No	Salt, sawdust glass rod, burner watchglass, tripod	No
Five	Distillation	*Problem stated * Step by step instructions and diagram on how to do the experiment.	No, but can make a list for improving the system - therefore slightly open-ended.	Yes	Yes	No	No	No	Distillation		Flask, tripod Meths burner	Yes, the Liebig Condenser.
Six	Preparing Limewater	*Prepare limewater * Step by step instructions * Experiment five gives expected result "The litmus paper should..."	Yes, but suggests that experiment two could be used to solve the problem.	Yes	No	No	Yes	Yes	Copper Sulphate	Yes	Calcium Hydroxide	Yes, but pupil, not teacher.

Form Two Prepared Unit - Material World. Chemistry (continued)

Lesson Number	Topic	Activity Type	Opportunity given for own investigation	Use of hand-on equipment	Application of knowledge to child's world	Analogy used	Clean up instructions given	Safety instructions given	Key Vocab.	Recording instructions given.	Equipment used.	Teacher Demon- -stration
Seven	Metal from a crystal	*No aim *Step by step instructions * Some expected results given.	No	Yes	No	No	No	Yes	Copper Sulphate	Yes	Copper sulphate solution Test tubes Nails	Yes X2

Mini Scientific Investigation -See sheet inclosed.

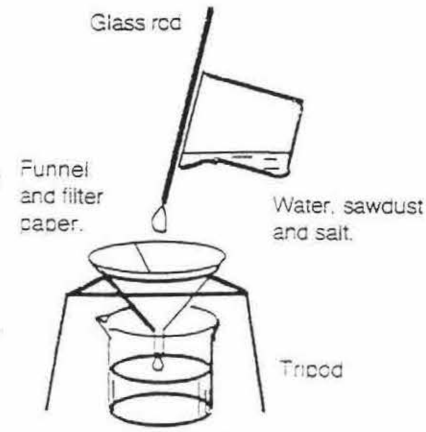
SEPARATION BY FLOTATION AND EVAPORATION

PROBLEM How can a mixture containing salt and sawdust be separated?

(1) Place two teaspoons of salt and about the same amount of sawdust in a small beaker. Mix with a glass rod.

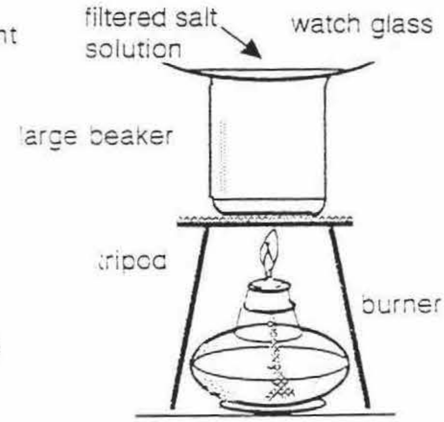
(2) Add between 70 and 80 ml. of cold water. Now stir the mixture of salt , sawdust and water thoroughly until the salt dissolves.

(3) Place a glass rod across the top of the beaker and decant the mixture through filter paper into the second small beaker. Decanting means pour the mixture down a glass rod into the filter paper. (See diagram)



The solution you collect in the second beaker should be clear.
Does it contain salt ?We are about to find out.

(4) Place 50 ml. of water (No more or your experiment will take too long to complete) in the large 200 ml beaker. Place this beaker on top of the gauze and tripod. Now place the watch glass on top of this large beaker. Into the watch glass place a small amount of your filtered salt solution.(The clear liquid in the second beaker) A picture is worth a thousand words , please refer to the diagram



SAFETY PRECAUTIONS You are going to boil the water in the large beaker. If the experiment tips over boiling water could get on your skin and it could leave you with a scar. **DON'T BUMP THE TRIPOD** with elbows , hands, clipboards, or your science book.

(5) As soon as the water starts to heat up observe the condensation on the insides of the beaker. What effect does the watch glass have on the rising vapour?
WARNING: Don't place your eyes or face close too close to this experiment. Relate what you see happening to clouds and rain.

(6) Observe what is left behind in the watch glass. Where did it come from? Before you discuss this with your teacher please turn your burner off.

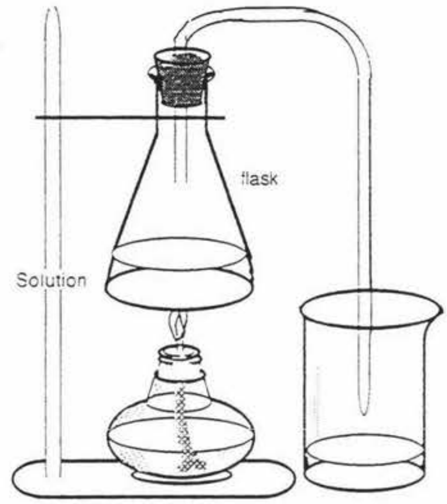
Now that the equipment has cooled down it is time to clean up.Place the used filter paper and sawdust in the dump buckets.Thoroughly wash the watch glass in a bucket of clean water.Be careful not to bang glass objects together while you are cleaning them. The rest of the clean up procedure is the same as for the last lesson.

DISTILLATION

PROBLEM : How can clean water be obtained from muddy or impure water?

EXPERIMENT 1.
Set up this distillation apparatus and list all of the problems associated with obtaining clear water from muddy water.

Start the experiment after the teacher has checked for safety.



We are using the process of DISTILLATION in this diagram.

RESULTS : List your results.

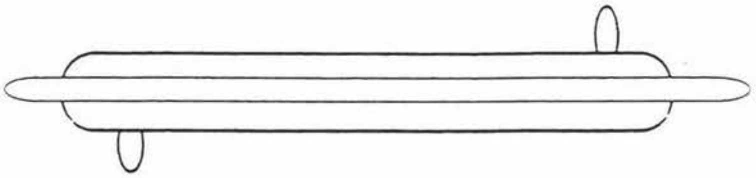
1.

2.

3.

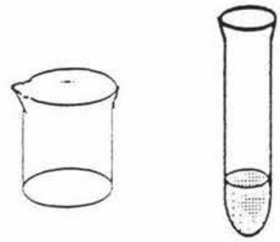
Make a list for improving the equipment so that no water is lost. Draw the best system.

After you have discussed the above, your teacher may demonstrate the **Liebig condenser**.



This diagram may give you a clue as to how it might work.

DISSOLVING AND CHEMICAL CHANGE



EXPERIMENT ONE

Take three test tubes and place water in each to a depth of 2 c. m. To test tube number one add a few crystals of sodium thiosulphate (white crystals). Watch them dissolve slowly. Discuss what might be happening.

To test tube number two add a few crystals of copper sulphate (blue crystals). After a time you will notice that they will not dissolve very quickly in cold water.

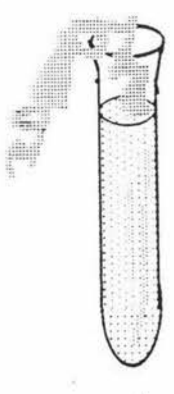
* **Discuss safety precautions** for the use of spirit burners, and the problem of liquids bumping when they are boiled in a test tube suddenly.

EXPERIMENT TWO

Add the same amount of copper sulphate as in experiment one to test tube number 3 and heat gently. Hold the test tube holder and keep the tube pointed away from people. Compare the rate of dissolving with test tube number 2 which probably will not have dissolved after several minutes. (Discuss possible reasons.)

EXPERIMENT THREE

After the heated tube of copper sulphate (blue crystals has completely dissolved place it in the test tube rack and allow to cool down. After the solution has completely cooled add 1.5 c. m. of its contents to an empty test tube together with an equal amount from test tube number 1 (sodium thiosulphate solution). Now heat the mixture of **sodium thiosulphate solution** and **copper sulphate solution** very slowly and very carefully.



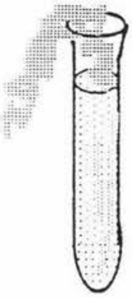
RESULTS

Under the heading results record any colour changes you observe.

WARNING : Once the mixture has gone dark brown or black stop heating as the mixture can easily bubble over and burn your hand.

NOTES FOR TEACHERS

LESSON ONE : DISSOLVING AND CHEMICAL CHANGE



DISCUSS : The relationship between temperature and the rate of dissolving. A teacher demonstration in lesson two will help explain this.

DISCUSS : chemical change. The original chemicals can't be easily extracted from the brown mixture as this chemical change is irreversible.

ANALOGY : the constituents of a cake mixture can be separated again but once the cake mixture has been heated and chemical changes take place between the constituents of the mixture you can never get your milk, flour and butter etc. back to their original state.

SUGGESTED PROCEDURE FOR CLEANING UP THE EQUIPMENT

(A) Two monitors will come around with the dump buckets. Please pour the contents of your test tubes into the dump bucket.

(B) Now rise the empty test tubes in the buckets of clean water provided. Brush them out and rinse again.

(C) Place the cleaned test tubes upside down on the drying pins on your test tube rack.

(D) monitors empty dump buckets down the sink and then rinse the buckets with clean water ready for the next class.

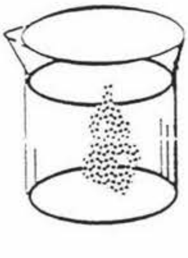
(E) PLACE ALL THE OTHER EQUIPMENT BACK IN ITS CORRECT PLACE IN THE BOX.

Please stay at your place while the monitors are refilling the buckets.

TEACHER DEMONSTRATION

EXPERIMENT 1 Fill a large beaker (2000 ml) with cold water and allow to stand for ten minutes so that all random movement ceases. Fill a second 2000 ml beaker with hot water.

Now place a few crystals of fluorescein onto the surface of the liquid in both beakers. Note the rate of spread of the colour throughout the liquid.



How does the rate of spread of the colour relate to the temperature of the liquid?

Do the particles of hot water move around faster than the particles of cold water?

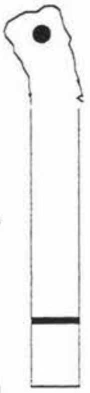
How could the speed of the water particles effect the rate of "colour spread?"

CHROMATOGRAPHY

THE PROBLEM OF SEPARATION

Many substances consist of particles of different kinds.

You may have already used filtering and distilling as methods of separating these particles. Both these processes make use of the **different properties** of the particles concerned. In filtering the different sizes of the particles. in distilling -- the different boiling points of the particles involved.

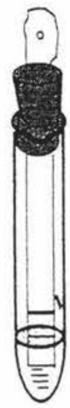


Another curious property of particles is that they may move through certain absorbent materials at **different speeds.** As the slower particles are left behind they become separated from the faster ones. If the particles are different colours the **separation** that results can easily be seen.

This method of separating substances is called chromatography. " chroma " meaning colour and " graphy " meaning to write.

In this investigation, you will be trying to separate the different pigments used in ball - point ink.

Equipment: ball-point pens and felt pens of various colours (include black) chromatography or filter paper, stoppered test tubes, solvent (2 water: 2 meths: 1 ammonia).



1. Cut the paper to fit into the test tube so that it does not touch the sides.
2. Draw a thick line of ball-pen on both sides of the paper about 2 c. m. from one end.
3. Fold the strip lengthways and stand it in the test tube which should have about 3ml of solvent in it, but not enough to reach the line you drew.
4. Remove the paper when the solvent has nearly reached the top.

Repeat the procedure using different coloured inks. It is also interesting to study the separations that occur if the solvents used are varied, that is , with more or less ammonia, meths or water.

In your science book write the heading **CHROMATOGRAPHY** and draw a diagram showing a test tube and paper a strip etc. Sellotape the strips you have run in your science book.

The process we used is called ----------- The word **'chroma'** means ----------- while the word **'graph'** means ----------------- .

PUPILS WORK SHEET

HOW TO DO A SCIENCE PROJECT

Like most worthwhile school work, a science project is not an easy job. It will require a lot of time, thought and just plain hard work. But you will receive plenty of satisfaction from a well done project, there are few better ways to understand what real science is all about.

Choosing a topic is often the hardest part of a science project.
Your choice may be easier if you realise that there are four different types of science projects:

1. A REPORT PROJECT - is really a written report based on what you have learnt from reading.
2. A COLLECTION PROJECT - is done by collecting objects such as rocks and finding some pattern in their properties.
3. A CONSTRUCTION PROJECT- involves making a device - such as an electric motor and then explaining how it works and testing various improvements.
4. A RESEARCH PROJECT- involves investigating and experimenting to answer a question. For example: Why do peeled apples go brown? Scientific thought and understanding is shown by well planned experiments with variable factors taken into account.

A research project is far more likely to win a prize than a report project because the judges award double points for the correct use of the **experimental method** and the scientific thought and understanding shown by your experiments and the conclusions you draw from them.

HOW DO I GO ABOUT IT?

Projects cannot be done at the last minute: they are the result of weeks ------ and sometimes months of preparation and practical effort. A well organised scientist should plan a weekly schedule as a countdown to the School Science Fair. When preparing this schedule think about:

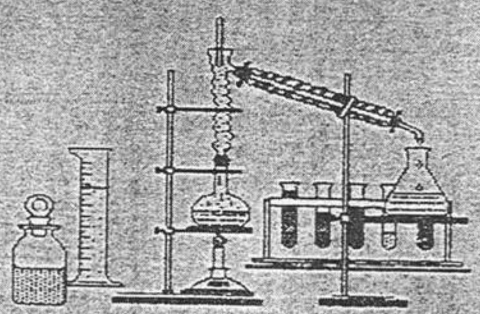
- How long will I take to complete my display?
- When should I start my experiments?
- Is the equipment I need available?
- How long will my experiments take?

Many factors may affect your project. You should try to anticipate any problems and plan ways of overcoming them. When you have completed your plan of action,you should **write the important dates of your schedule on a calendar**.

DEADLINES

Projects must be available for evaluation in classrooms on the **19th of June.**
They will be put on display in the hall on the **26th of June.**

Science Fair IS



Commendable Effort

Presented to
for their entry in
the 1995 Science Fair

26 June 1995

N.Z. SCIENCE TEACHERS ASSOCIATION

TOPIC: HOME CHEMISTRY

** Build a small meths burner usiňg a small glass bottle and cotton wool as a wick. Your burner must contain less than a quarter of a cup of meths when full. CAUTION: do not use any other liquid in your burner and only use it with an adults permission. Show is to your teacher.

** Construct a small tripod to go with your burner, perhaps using a small tin. Demonstrate your burner and tripod to your teacher by boiling some water in a small can. Time how long it takes to boil half a cup of water.

** Make a funnel by cutting the top third off a plastic soft drink bottle. Use a circle of paper towel as filter paper. Demonstrate how it works to your teacher by filtering a mixture of soil and water.

** A mixture of colours can be separated using paper chromatography. Cut a strip of paper towel 20 cms long and 2 cms wide. Place small dots of either food colouring or water based felt pen 2 cm from the bottom. Suspend the strip in a glass with 1 cm of water in the bottom. Make sure the dots of colour are about the water level. Leave until the water has soaked 3/4 of the way up the strip. Remove the strip from the water and leave to dry. Mount your strips on a chart and label.

*** Construct an acid-base indicator by boiling some red cabbage leaves in a small amount of water. Add lemon juice or vinegar to a small sample of the indicator and record the colour. This colour indicates that a substance is basic. Test the acidity of several household substances are record the results on a chart. Note: black tea is also a good indicator as are the liquids obtained from boiling flowers.

** Find out what electrolysis is and write a brief report. Submerge a 9 volt battery upright in a glass containing water and ½ teaspoon of salt. Report what occurs and offer an explanation.

*** Construct a simple meter by winding several coils of insulated wire, in the same direction, around a charm compass. Connect one end of the wire to a galvanised nail and connect the other end to a copper nail (or copper wire) Place both nail;s into a glass containing vinegar and observe what happens to the needle in the compass. Record your observations. Include a diagram of your apparatus.

*** Compare cleaners. Dissolve one teaspoon of a household cleaner in ½ glass of water. Stir and allow to settle. Record how much solid abrasive material is present. Repeat for other cleansers and record your findings on a chart.

** Work out a method which would enable you to distinguish between sugar and salt without tasting them. Give an oral account and demonstrate.

** Make up a saturated solution of salt by stirring salt into a glass of hot water until no more will dissolve. Leave to cool and then suspend a small crystal of salt on a length of cotton in the solution. Observe over the next week and provide drawings of the different stages with notes.

** Design an experiment that tests the amount of salt the must be in water before it will not freeze when left overnight in your freezer. Record your method. Repeat using sugar to receive an extra star.

There are further task options on the back of this sheet.

HOME CHEMISTRY

Appendix Two

Teacher letters and instruments

Contents

MASSEY UNIVERSITY

Organisational Culture and Attitudes to Science in an Intermediate School

Information Sheet for Teacher's Interview

Dear Teacher,

I am Anne Bowmar, also a teacher at Intermediate School. Currently I am writing a thesis entitled: Organisational Culture and Attitudes to Science in an Intermediate School for a Master of Education degree through Massey University in Palmerston North. My supervisor is Dr Janet Burns. As part of his study I am investigating attitudes to science and science teaching amongst the staff at Intermediate School. You are invited to participate in an interview as part of this study.

The interview will be conducted at a time convenient to you. I will be asking questions about your previous science learning, attitudes towards science and its teaching these interviews will be audiotaped and transcribed back. They will take approximately twenty minutes to half an hour. You will be given a transcript of the interview as soon as it has been transcribed. When transcription is complete, you may have the tape or have it destroyed.

If you agree to take part in this interview you will have the right to refuse to answer any particular question and to withdraw from the study at any time and to leave the room at any time. You will be able to turn the tape recorder off at any time. You will also be able to ask any further questions about the study that occur to you at any time during your participation.

You will be providing information on the understanding that it is completely confidential to the researchers (myself and Dr Burns my supervisor). All information is collected anonymously and it will not be possible to identify you in any reports that are prepared from this study.

If you agree to participate, please indicate your consent on the form enclosed. If you have any queries regarding this please feel free to discuss these with me.

Yours sincerely
Anne Bowmar

MASSEY UNIVERSITY

Organisational Culture and Attitudes to Science in an Intermediate School

Teacher consent form for interview

I have read the Information Sheet for this study and have had the details of the study explained to me. My questions about the study have been answered to my satisfaction and I understand that I may ask further questions at any time.

I also understand that I have the right to withdraw from the study at any time and decline to answer any particular questions in the study. I also understand that I may turn off the tape recorder at any time. I agree to provide information to the researchers on the understanding that it is confidential.

I wish to participate in the study under the conditions set out in the Information Sheet.

Signed: Teacher:____

Name: Teacher: ____

Staff Interview Schedule

Questions addressed to classroom teachers and management:

1. What science did you do at school?
2. Did you enjoy the science that you did do?
3. What science did you do at Teachers' College?
4. Have you undertaken any Science Education courses since then?
5. How many years have you been teaching?
6. How long have you taught at Bayside school?
7. How would you describe your attitudes to teaching science? - on a scale from one to ten, one being negative, five being in the middle and ten being very positive.
8. What values do you see underpinning science delivery in this school?
9. Could you please comment on the Science Fair?
10. Could you please comment on the Science Badges?
11. Generally is there anything else you would like to add?

Additional management question:

1. How do you see the management of the school supporting the teachingof science?

Technicraft Teachers question:

1. How do you view the subject you teach in relation to science?

TEACHER PRACTICE SELF-EVALUATION
SCIENCE TEACHING

As part of my thesis study on Organisational Culture and Attitudes to Science I have devised the following "teacher practice self-evaluation" scale. You are invited to complete it. I have done this because it is difficult for me to observe science teaching in every classroom (and you may not want me there!) It is made up of the items from the scheme and from the National Curriculum document. The questionnaire is anonymous.
Please answer as accurately and honestly as you can.

How often do you, when teaching science...?

		In every topic	In most topics	In some topics	Never
1.	Establish the students' "before views"?	☐	☐	☐	☐
2.	Establish the students' "before views" using methods other than a pen and paper test?	☐	☐	☐	☐

3. What other methods do you use? ______________________________

		In every topic	In most topics	In some topics	Never
4.	Use the students' ideas/beliefs as as basis for learning?	☐	☐	☐	☐
5.	Introduce scientific knowledge skills and attitudes in a context relevant and familiar to the students?	☐	☐	☐	☐

6. Can you give examples of contexts you have used or are planning to use? ______________________________

		In every topic	In most topics	In some topics	Never
7.	Do you make up your own units?	☐	☐	☐	☐
8.	If using a prepared unit, do you include material extra to what is provided?	☐	☐	☐	☐
9.	Ensure that assessment is ongoing and that pupils are involved with it?	☐	☐	☐	☐

How often do you, when teaching science...?

	Every lesson	Most lessons	Some lessons	Never
10. Try to help students see the relevance and usefulness of science to themselves and society?	☐	☐	☐	☐
11. Challenge children?	☐	☐	☐	☐
12. Expect children to achieve?	☐	☐	☐	☐
13. Have a well established classroom routine?	☐	☐	☐	☐
14. Encourage a positive relationship between teacher and student?	☐	☐	☐	☐
15. Ensure learning objectives are clear to the students?	☐	☐	☐	☐

How often do your students?

	In every topic	In most topics	In some topics	Never
1. Develop their own investigation to test using fair testing methods?	☐	☐	☐	☐
2. Describe what they have investigated and what they now understand?	☐	☐	☐	☐
3. Have opportunities to use new ideas/skills in a familiar context first?	☐	☐	☐	☐
4. Have opportunities to use new skills/ideas in challenging situations later?	☐	☐	☐	☐

* * * * * * * *

Feel free to add anything else you would like to or anything you would like to qualify...

Appendix Three

Student letters, instruments and factor analyses

Contents

Attitude to Science Questionnaire

As part of Miss Bowmar's University study, she is trying to find out what students at think about science. You are invited to answer this questionnaire.

* It will take approximately 15 minutes.
* There are three parts to this booklet.
* The first two parts are about what you think of science.
* The third part at the end is where you can add anything you would like to about science or science at this school.

There are no "right" or "wrong" answers. It is important that you answer them as honestly and accurately as you can.

Thank you for participating in this study. This information is being used for research only and will be confidential to the researcher.

Please fill in this box. You do not need to write your name.

I am in Form ____________

I am a girl (circle which one)

I am a boy (circle which one)

Which ethnic group/s do you feel you belong to?
You may tick more than one if you feel you belong to more than one group:

- Maori ☐
- European ☐
- Korean ☐
- Chinese ☐
- Japanese ☐
- Taiwanese ☐
- Samoan ☐
- Fijian ☐
- Other ☐

Please specify ______________

PART 1

In science, some topics may interest you more than others. In this questionnaire you should tick "I'd like to know more" or "Not sure" or "Not interested" depending how you feel about each topic.

	I'd like to know more	Not sure	Not interested	
1. How a heart works				
2. Torches and batteries				
3. Life in the sea				
4. How a record is made				
5. Fossils				
6. Different kinds of trees				
7. How insects live				
8. How machines work				
9. Germs and illnesses				
10. How electricity is produced				
11. Time				
12. Our ears and how we hear				
13. What baking powder does				
14. Volcanoes and earthworks				
15. How transistor radios work				
16. Water				
17. How our muscles work				
18. Light				
19. What food is good for you				
20. How vacuum cleaners work				
21. Animals in the jungle				
22. Acids and chemicals				
23. How children develop				

	I'd like to know more	Not sure	Not interested	
24. Nuclear power				
25. How sound passes through air				
26. Birds eggs and nests				
27. What makes a rainbow appear				
28. Different kinds of rocks				
29. Why some animals hibernate				
30. Atoms and molecules				
31. Our eyes and how we see				
32. The stars and planets				
33. Drugs				
34. Computers				
35. How a bicycle pump works				
36. The air we breathe				
37. What magnets do				
38. How caterpillars change into butterflies				
39. What gravity is				
40. How motorcars work				
41. The weather				
42. How seeds grow into flowers				

PART TWO

In this questionnaire there are statements about science and scientists. Please place a tick in the box "Yes I agree" or "Not sure", or "No I disagree" depending on what you think.

	Yes, I agree	Not sure	No, I disagree
1. I like fiddling with machinery			
2. Science is making things better all the time			
3. Girls are very good at using tools			
4. Scientists do not care about people			
5. In science most of the answers are already known			
6. Science is useful whatever you do when you leave school			
7. Science is fascinating			
8. Scientists are a bit weird			
9. Computers are taking over the world			
10. I want to learn all I can about science			
11. A woman could never be a great scientist			
12. Science makes things which are a nuisance			
13. Scientists do lots of things which are dangerous			
14. Science is a very difficult subject			
15. Science does more harm than good			
16. It's useful to know about science when you are bringing up children			
17. Scientists are always forgetting things			
18. Engineering is a very dirty job			
19. I'd like to be given a science book as a present			

	Yes, I agree	Not sure	No, I disagree
20. Girls don't need to know about electricity or light			
21. Money spent on science should be put to better use			
22. Scientists should never guess what will happen in their experiments			
23. Knowing science will help me to earn a living			
24. Girls who want to be scientists are a bit peculiar			
25. Science is very exciting			
26. Most scientists are ugly			
27. Lots of information we get from science now will be changed in the future			
28. I'd like to have a job making things			
29. Science is to blame for killing millions of people			
30. Only people who want to become scientists should have to study science			
31. Science is dangerous for everyone			
32. When I start thinking about science I find it hard to stop			
33. Learning science is more important for boys than for girls			
34. Scientists never talk about anything except science			
35. Science is destroying the beauties of nature			
36. I like finding out how things work			
37. Science teaches us not to believe everything we are told			
38. My father thinks I will be good at science			

	Yes, I agree	Not sure	No, I disagree	
39. The results of science are making life too much of a rush				
40. Science is only for brainy people				
41. Boys don't need to learn about animals and flowers				
42. People have managed without science for a long time and we should be able to manage without science too				
43. There are too many facts to learn in science				
44. Girls don't need to know how things work				
45. Science is polluting the world				
46. I've always been interested in learning science				
47. You have to be very strong to be an engineer				
48. You can't use your imagination in science				
49. Science doesn't effect my life				
50. Science is making most people's jobs more boring				
51. I don't expect I'll be any good at science				
52. I'd like to have a job using science				
53. Everyone needs to understand the modern world				
54. Scientists don't seem to be very happy				
55. Girls are just as good as boys at science				
56. Science is reducing our freedom				
57. There are too many facts to learn in science				
58. Scientists are boring people				

PART THREE

If there is anything else you would like to add about science and/or science at Intermediate School, you can write it in the space below:

Thank you for participating in this study.

MASSEY UNIVERSITY
Private Bag 11222
Palmerston North
New Zealand
Telephone 0-6-356 9099
Facsimile 0-6-350 5635
FACULTY OF EDUCATION
DEAN'S OFFICE

MASSEY UNIVERSITY

Organisational Culture and Attitudes to Science in an Intermediate School

Parents/Guardians and Students information sheet for focus group interview.

Dear Parent/Guardian and student,

I am Anne Bowmar, a teacher at Intermediate School. Currently I am writing a thesis entitled " Organisational Culture and Attitudes to Science in an Intermediate School " for a Master of Education degree through Massey University in Palmerston North. My supervisor is Dr Janet Burns. As part of this study, I am investigating attitudes to science amongst students at Intermediate School. Your child is being invited to participate in an interview as part of this study.

The students will be interviewed in groups. They will be asked questions about their attitudes towards science and their attitudes to the science programme at Intermediate School. These interviews will be videotaped and transcribed back. They will take approximately half to three quarters of an hour for each group of eight students. The outcomes will be reported back to each group involved. The tapes will be viewed only by myself and my supervisor, Dr Janet Burns of Massey University in Palmerston North and will be stored in a locked filing cabinet when not in use.

If your child agrees to take part in this study s/he will have the right to refuse to answer any particular question and to withdraw from the study at any time and to leave the room at any time. S/he will also be able to ask any further questions about the study that occur to them at any time during their participation.

Your child will be providing information on the understanding that it is completely confidential to the researchers (myself and Dr Burns my supervisor). All information is collected anonymously and it will not be possible to identify your child in any reports that are prepared from the study.

Your child will be given access to a summary of the findings from the study when it is concluded.

Your child has indicated that s/he would be interested and willing to take part in this group interview. If you agree to her/his participation, please indicate on the form enclosed. There are spaces for both your child and yourself/yourselves to indicate permission.

The interviews will take place during the second half of term three this year.

If you have any queries regarding this, please feel free to contact me through the school office on

Yours sincerely
Anne Bowmar Anne Bowmar

MASSEY UNIVERSITY
Private Bag 11222
Palmerston North
New Zealand
Telephone 0-6-356 9099
Facsimile 0-6-350 5635

FACULTY OF EDUCATION

DEAN'S OFFICE

MASSEY UNIVERSITY

Organisational Culture and Attitudes to Science in an Intermediate School

Parent/Guardian and student consent form for group interview.

I have read the Information Sheet for this study and have had the details of the study explained to me. My questions about the study have been answered to my satisfaction and I understand that I may ask further questions at any time.

I also understand that I have the right to withdraw from the study at any time and to decline to answer any particular questions in the study. I agree to provide information to the researchers on the understanding that it is confidential.

I wish to participate in this study under the conditions set out on the Information Sheet.

Signed: Student: ______________________________

Name: Student: ______________________________

Signed: Parent/Guardian: ______________________________

Name: Parent/Guardian: ______________________________

Table One

Science Curiosity Inventory: Open Principal Component Analysis

Items	Ft 1	Ft 2	Ft 3	Ft 4	Ft 5	Ft 6	Ft 7	Ft 8	Ft9
	Factor Loadings								
How machines work	.76	.04	-.12	.14	-.03	.08	.01	-.07	-.02
How transistor radios work	.72	.01	-.03	-.06	.03	.04	.10	.13	.00
How motorcars work	.71	.09	-.02	.04	-.03	.12	-.06	.04	-.11
Torches and batteries	.65	.04	.10	.01	.21	-.17	.06	-.02	.12
Computers	.65	-.13	-.02	-.01	.09	.12	.11	-.02	.11
How electricity is produced	.56	.30	.06	-.09	.17	-.04	.27	-.08	-.02
Nuclear power	.55	.16	-.13	-.03	.11	.19	-.15	-.04	-.30
How a bicycle pump works	.54	.16	-.13	-.03	.11	.02	-.00	-.34	-.33
Atoms and molecules	.53	.26	-.03	-.14	.39	.20	-.10	.08	-.10
What magnets do	.48	.13	.46	.05	-.01	-.12	.12	.16	-.02
Light	.41	.34	.03	.02	.32	-.21	.30	.15	-.01
Our eyes and how we see	.12	.68	.13	.06	.17	.10	.06	.10	.21
How a heart works	.04	.67	.06	.21	-.02	.17	.10	-.07	-.15
Our ears and how we hear	.02	.67	.15	.10	.08	.22	.02	.20	.16
The air we breathe	.11	.63	.23	.12	.03	-.07	.26	.03	.15
How our muscles work	.06	.55	.11	.19	.01	.36	.18	-.06	-.03
How sound passes through air	.32	.49	.25	-.06	.19	-.11	.11	.07	-.01
What gravity is	.31	.37	.36	.02	.27	.06	.19	-.13	-.25
How caterpillars change into butterflies	.02	.20	.68	.20	-.02	-.08	-.09	-.01	.08
Why some animals hibernate	-.09	.13	.60	.37	.06	.19	.05	.10	-.16
How seeds grow into flowers	-.06	.20	.59	.22	.18	-.04	.21	-.05	.20
What makes a rainbow appear	-.07	.19	.55	.01	.10	.03	.32	.24	.10
Animals in the jungle	-.04	-.09	.32	.66	-.00	.10	.15	.03	-.12
How insects live	.13	.29	.15	.65	.07	-.01	-.09	.03	.17
Life in the sea	-.08	.06	.17	.64	.09	.03	.19	-.07	.03
Different kinds of trees	-.02	.30	.05	.60	.23	-.17	.07	.07	.16
Birds eggs and nests	-.14	.13	.45	.48	.10	-.04	.04	.23	.20
Volcanoes and earthquakes	.27	.11	-.07	.46	.42	.10	-.06	.27	-.21

Table 1 continues over

Table One — (continues)

Items	Ft 1	Ft 2	Ft 3	Ft 4	Ft 5	Ft 6	Ft 7	Ft 8	Ft9
	Factor Loadings								
The stars and planets	.14	.16	.03	.14	.62	.04	.27	.05	.08
Fossils	.12	.11	.27	.21	.52	.15	-.14	-.17	.01
Different kinds of rocks	.12	-.06	.45	.31	.47	.04	-.06	.14	.01
Drugs	.11	.09	-.07	-.01	.05	.71	-.10	.06	.10
Germs and illnesses	.02	.35	.03	.08	.10	.64	.17	-.17	.09
How a record is made	.35	.06	.12	-.09	-.24	.40	.40	.12	.06
Water	-.02	.21	.13	.25	.16	.01	.62	.21	-.02
Time	.23	.29	.05	.09	-.03	.03	.59	.01	.15
Weather	.08	.28	.33	.21	.36	.04	.37	-.04	.05
What baking powder does	.06	.05	.11	.12	.07	-.02	.15	.76	-.03
How vacuum cleaners work	.43	.20	.29	-.02	-.20	.09	.02	.44	.15
How children develop	.04	.21	.16	.12	.14	.29	.10	-.04	.64
What food is good for you	-.22	.33	-.00	.33	.02	-.04	.19	.14	.38
Percentage of Variance	**20.6**	**11.3**	**5.2**	**4.5**	**3.6**	**2.9**	**2.6**	**2.5**	**2.4**

Table Two

Science Curiosity Inventory: Four Factor Analysis

Items	Factor Loadings			
	Factor 1	Factor 2	Factor 3	Factor 4
How machines work	.71	-.01	.02	.08
How motorcars work	.69	-.03	.04	.12
Atoms and molecules	.68	.04	.23	-.03
How transistor radios work	.67	-.08	-.00	.26
Nuclear power	.66	-.05	.08	-.14
Computers	.61	-.03	-.03	.15
Acids and chemicals	.61	-.00	.12	-.10
Torches and batteries	.58	.11	-.04	.29
How electricity is produced	.54	-.01	.27	.28
Light	.41	.16	.22	.34
What gravity is	.37	.28	.33	.17
Different kinds of rocks	.19	.65	-.05	.11
Animals in the jungle	-.08	.64	-.00	.06
Birds eggs and nests	-.22	.61	.12	.30
Life in the sea	-.12	.59	.14	.01
Different kinds of trees	-.05	.59	.21	.10
How insects live	.06	.58	.23	.09
Why some animals hibernate	-.08	.58	.17	.18
Volcanoes and earthquakes	.41	.52	.05	-.11
Fossils	.23	.51	.18	-.13
How seeds grow into flowers	-.13	.50	.26	.36
The weather	.11	.46	.37	.23
How caterpillars turn into butterflies	-.08	.44	.10	.38
The stars and the planets	.27	.40	.25	.03
Germs and illnesses	.14	.08	.66	-.21
Our ears and how we hear	.06	.18	.66	.18
How our muscles work	.11	.18	.66	.01
Our eyes and how we see	.13	.18	.63	.22
How a heart works	.08	.17	.63	.01

Table 2 continues over

Table Two — (continues)

Items	Factor Loadings Factor 1	Factor 2	Factor 3	Factor 4
The air we breathe	.04	.20	.57	.39
How children develop	-.01	.19	.46	.14
Time	.13	.04	.43	.38
Drugs	.25	-.05	.39	-.28
What food is good for you	-.30	.27	.38	.18
How sound passes through air	.31	.14	.35	.35
Water	-.04	.31	.34	.33
How a record is made	-.28	-.18	.31	.30
How a bike pump works	.38	.02	.04	.57
How vacuum cleaners work	.31	.00	.15	.56
What magnets do	.37	.21	.03	.54
What makes a rainbow appear	-.12	.29	.26	.50
What baking powder does	.06	.20	-.01	.43

Table Three

Science Curiosity Inventory: Smail and Kelly's (1984) factors

Physical Science

How machines work
How motor cars work
Atoms and molecules
How transistor radios work
Nuclear power
Computers
Torches and batteries
Light
What gravity is
How a bicycle pump works
How vacuum cleaners work
The stars and planets
What magnets do
Time
How electricity is produced

Nature Science

Different kinds of rocks
Birds eggs and nests
Different kinds of trees
Why some animals hibernate
How seeds grow into flowers
The weather
How caterpillars change into butterflies
What food is good for you
Water

Human Biology

How a heart works
Germs and illness
Our ears and how we hear
How our muscles work
How children develop
Our eyes and how we see
Drugs
The air we breathe
How sound passes through air (P)

TV Science

Acids and chemicals
Animals in the jungle
Fossils
Life in the sea
How insects live
Volcanoes and earthquakes

Not included on any factor for calculations

What makes a rainbow appear
What baking powder does
How a record is made

Table Four

Image of Science Inventory: Open Principal Component Analysis

Items	Factor Loadings Factor 1	Factor 2	Factor 3	Factor 4	Factor 5
I've always been interested in learning science	.79	.11	-.00	.07	.10
I want to learn all the science I can	.79	.13	.01	.14	.06
Science is very exciting	.74	.13	.11	.07	.07
I want to have a job using science	.70	.13	-.02	.01	.20
Science is fascinating	.67	.08	.11	.09	.02
I'd like to be given a science book as a present	.64	.11	.08	-.01	.04
I like finding out how things work	.68	.16	.02	.16	.00
When I start thinking about science I find it hard to stop	.60	-.01	-.05	-.01	-.02
My father thinks I will be good at science	.49	-.08	-.00	.02	.28
I would like a job making things	.46	.06	.05	-.05	.09
I am no good at science(x)	.46	.17	.07	.02	.21
Knowing science will help me earn lots of money	.41	.11	.12	.16	.07
Scientists are boring people	.37	.30	.26	.30	.16
Science is polluting the world	.16	.75	.06	.10	.07
Science is destroying the beauties of nature	.17	.70	.05	.13	.06
Science is responsible for killing millions of people	.04	.66	.06	.13	.10
Science is reducing our freedom	.13	.65	.14	.01	.04
Science is making the world a rush	.13	.63	.09	-.01	.21
Money spent on science is a waste	.22	.47	.10	.26	.13
Science does more harm than good	.11	.46	.23	.05	.20
Science is a nuisance	.11	.43	.18	.21	-.04
Scientists do not care about people	-.01	.43	.17	.29	.06
Science is making people's jobs more boring	.33	.37	.15	.06	.06

Table 4 continues over

Table Four — (continues)

Items	Factor Loadings Factor 1	Factor 2	Factor 3	Factor 4	Factor 5
Girls don't need to know about electricity	.06	.17	.75	-.03	.04
Girls don't need to know how things work	.14	.14	.70	.10	.02
Girls who want to be scientists are a bit peculiar	.07	.15	.70	.01	.06
A woman could never be a great scientist	.00	.06	.68	.08	-.03
Science is more important for boys than girls	.03	.10	.67	.03	.11
Girls are as good as boys at science	-.09	.01	.65	.06	.04
Girls are good at using tools	-.03	-.05	.53	.03	.15
Boys don't need to know about animals or plants	.06	.15	.53	.29	-.01
Scientists are a bit weird	.16	.15	.03	.69	.05
Scientists only talk about science	.09	.11	.18	.48	.17
Scientists are forgetful people	.02	.27	.23	.44	.05
Scientists are not very happy people	.15	.27	.19	.44	.15
Science is useful when you leave school	.29	-.01	-.09	.43	.06
There are too many facts to learn in science (X)	.22	.24	.11	.11	.79
There are too many facts to learn in science (X)	.23	.25	.10	.14	.79
Scientists are brainy people (X)	.23	.09	.33	.01	.41
Percentage of Variance	**19.6**	**7.3**	**4.8**	**3.4**	**2.9**

Table 4 continues over

Table Four — (continues)

Items	Factor Loadings				
	Factor 6	**Factor 7**	**Factor 8**	**Factor 9**	**Factor 10**
Engineering is a very dirty job (X)	.71	.02	-.03	.12	-.09
Science is dangerous (X)	.49	.04	-.01	.00	.07
Science is a difficult subject (X)	.07	.62	.08	.09	.11
Computers are taking over the world	-.21	.62	-.08	.01	-.29
All the information we get from science will be changed in a few years (X)	-.03	-.00	.82	-.01	.10
Science doesn't effect my life (X)	.11	.13	.05	.66	.12
People have managed without science for a long time and they should be able to manage without it too	.14	-.02	-.20	.45	.17
Science is necessary to understand the modern world (X)	-.06	-.08	.07	.14	.73
Percentage of Variance	**2.6**	**2.4**	**2.3**	**2.2**	**2.1**

Table 4 continues over

Table Four — (continues)

Items	Factor Loadings Factor 11	Factor 12	Factor 13	Factor 14	Factor 15
Science is making things better all the time	.63	.07	-.08	.04	-.05
Science is useful when you bring up children (X)	.23	.61	.06	-.00	.11
Scientists should never guess (X)	-.11	.49	.10	-.07	.05
Only people who want to be scientists should have to study science (X)	-.10	.39	.18	.04	.02
In science all the answers are already known (X)	-.05	.08	.75	.04	-.04
You have to be strong to be an engineer (X)	.12	.03	-.04	.65	.15
I like fiddling with machinary (X)	-.17	-.04	.08	.59	-.14
You can't use any imagination in science (X)	-.05	.09	-.05	.06	.68
Most scientists are ugly	.09	-.03	.19	-.07	.37
Percentage of Variance	**2.0**	**1.9**	**1.9**	**1.9**	**1.8**

Items	Factor Loadings Factor 16
Science teaches us not to believe everything we see	.84
Percentage of Variation	**1.7**

Table Five

Image of Science Inventory: Four factor analysis

Items	Factor Loadings Factor 1	Factor 2	Factor 3	Factor 4
I've always been interested in learning science	.77	.15	.18	-.03
I want to learn all the science I can	.76	.22	.06	.01
Science is very exciting	.72	.18	.03	.11
I want to have a job using science	.68	.07	.18	.10
I like finding out how things work	.68	.16	-.07	.10
Science is fascinating	.65	.16	-.04	.13
I'd like to be given a science book as a present	.60	.09	.08	-.01
When I start thinking about science I find it hard to stop	.57	-.03	.21	-.06
Knowing science will help me earn lots of money	.53	.07	.16	.18
My father thinks I will be good at science	.49	-.06	.30	-.01
I would like a job making things	.49	-.08	-.10	.02
I am no good at science (X)	.48	.17	.37	.05
Science is useful when you bring up children (X)	.46	.01	.08	.21
Scientists are boring people	.41	.33	.37	.27
Science is useful when you leave school	.39	.10	.15	-.04
I like fiddling with machinary (X)	.31	-.23	.01	-.11
Science is necessary to understand the modern world (X)	.28	.10	.08	-.05
All the information we get from science will be changed in a few years (X)	.22	-.10	-.16	.09
Science is responsible for killing millions of people	.05	.72	-.04	.08
Science is polluting the world	.17	.69	.14	.01
Science is destroying the beauties of nature	.20	.65	.10	.01
Science is making the world a rush	.17	.63	.14	.06

Table 5 continues over

Table Five — (continues)

Items	Factor 1	Factor 2	Factor 3	Factor 4
Science is reducing our freedom	.15	.61	.17	.10
Science is a nuisance	.09	.56	.16	.13
Money spent on science is a waste	.27	.52	.25	.09
Science is dangerous (X)	.03	.48	.28	.10
Science does more harm than good	.21	.48	.31	.23
Scientists do not care about people	.00	.46	.18	.20
People have managed without science for a long time andthey should be able to manage without it too	.06	.43	.27	.08
Science is making people's jobs more boring	.32	.41	.29	.14
Computers are taking over the world	-.03	.35	.06	.06
Science is making things better all the time	.31	.34	-.24	.10
Science teaches us not to believe everything we see	.13	-.30	.10	-.05
Scientists do things which are dangerous	-.05	.30	.29	-.07
There are too many facts to learn in science (X)	.34	.23	.48	.10
There are too many facts to learn in science (X)	.30	.28	.48	.07
Engineering is a very dirty job (X)	-.06	.06	.48	-.02
Science is a difficult subject (X)	.06	.09	.45	-.05
Scientists should never guess (X)	.08	.23	.45	.09
Scientists are not very happy people	.21	.39	.44	.20
Science doesn't effect my life (X)	.09	-.13	.43	.16
Most scientists are ugly	.28	.29	.43	.25
Only people who want to be scientists should have to study science (X)	.16	.13	.41	.28
Scientists only talk about science	.09	.35	.41	.18
Scientists are forgetful people	.07	.29	.41	.20
Scientists are brainy people (X)	.23	.15	.38	.31
In science all the answers are already known (X)	-.01	.04	.38	.12

Table 5 continues over

Table Five — (continues)

Items	Factor 1	Factor 2	Factor 3	Factor 4
You have to be strong to be an engineer (X)	-.00	.03	.35	.15
Scientists are a bit weird	.18	.19	.34	.04
You can't use any imagination in science (X)	.16	.09	.28	.10
Girls don't need to know about electricity	.06	.14	.08	.72
Science is more important for boys than girls	.03	.15	.14	.68
Girls who want to be scientists are a bit peculiar	.06	.16	.22	.66
Girls are as good as boys at science	.30	.03	.05	.66
Girls don't need to know how things work	.10	.19	.16	.65
A woman could never be a great scientist	-.02	.09	.12	.64
Girls are good at using tools	-.02	-.01	-.03	.59
Boys don't need to know about animals or plants	.02	.15	.19	.51

X= Not computed into Smail and Kelly's (1984) factors

Table Six

Image of Science Inventory (Smail and Kelly, 1984): Factor memberhip.

Liking of Science

I've always been interested in science
I want to learn all I can about science
Science is very exciting
I' d like to have a job using science
I like finding out how things work
Science is fascinating
I'f like to be given a science book as a present
When I start tinking about science I find it hard to stop
Knowing science will help me earn a living
I'd like to have a job making things

Science in the World

Science is to blame for killing millions of people
Science is polluting the world
Science is destroying thebeauties of nature
The results of science are making life too much of a rush
Science is reducing our freedom
Science makes things which are a nuisance
Money spent on science could be put to better use
Science does more harm than good
Scientists do not care about people
People have managed without science for a long time and they should be able to manage without science too
Science is making people's jobs more boring

The Image of Scientists

Scientists don't seem to be very happy
Most scientists are ugly
Scientists never talk about anything except science
Scientists are always forgetting things
Scientists are a bit weird

Science as a Male Persuit

Girls don't need to know about electricity or light
Learning science is more important for boys than girls
Girls who want to be scientists are a bit peculiar
Girls are just as good as boys at science
Girls don't need to know how things work
A woman could never be a great scientist
Girls are very good at using tools
Boys don't need to know about animals and flowers

Student focus group questions

Introduction:

Researcher: At this school the science programme is made up of lessons with your class, science badges, science fair and for some people, science extension. You've told me a lot in your questionnaires. Now I would like to explore some of the things more deeply with you. So we all have a chance to talk, after each question let's answer from left to right, and then once each person has had a say, we'll open the question for general discussion.

Part One: Likes/Dislikes:

- What do you like doing in science?
- Is there anything else you like doing?
- Why do you like doing these things?
- Are there any things you don't like doing in science?
- Why do you not like doing these things?

Researcher: In the surveys many students put that they wanted to do more fun and exciting experiments or activities:

- What do you think they meant by a fun or exciting activity or experiment?
- What would you give as an example of a fun or exciting experiment or activity?
- What makes that fun or exciting?

Researcher: Many students also put that they wanted more interesting activities or experiments.

- What is an interesting activity or experiment?
- Can you give an example of one?
- What makes this an interesting activity or experiment.
- What is a boring experiment or activity?
- Can you give an example of one?
- What makes that boring?

Researcher: Some students also put that they wanted more fun and exciting topics

- Can you give an example of one?
- What make that a fun or exciting topic?

Researcher: Some students put that they wanted more interesting topics.

- What is an interesting topic?
- What makes that an interesting topic?
- What is a boring topic?
- What makes that a boring topic?

Part Two: Understanding:

Researcher: Some students put in their surveys that when they understood science they enjoyed it more.

- Any comment?
- Tell me about something you understand in science and how you know you understand it.
- How do you feel when you understand in science?
- Tell me about something you don't understand in science and how you know you don't understand it.
- How do you feel when this happens?
- What do you do when you don't understand in science lessons, do you go to your teacher or to other people? Why?
- What sort of lessons help you understand best ... describe a lesson you understood well.

Part Three: Science at Home:

- Do you do any science in you own time?
- How much time would you spend on this?
- What sort of things do you do?
- What is the most exciting science thing you have done in your own time? Why was thins is most exciting thing?
- What do the adults at home think of you doing science things in your own time?