The nature of science education: does it cause female students' disaffection with science

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Abstract

This thesis seeks to answer the question 'Why are students disaffected with science?' Students' disaffection is described in terms of their dislike for science education. Support for the idea that students dislike science is found within the literature reviewed. A possible answer is in the nature of science education. Thus rather than the problem lying with students not understanding science ideas within the education system, it may be that the science is simply impossible to understand. So a major part of the nature of science education is that it is impossible to understand.

This possibility is explored with a group of 74 female Bachelor of Education students. The students' perceptions of science are explored, using a research methodology based around interviews about past events. The students' perceptions of science were that they as students did not like it and that it was not understandable. At this point, it was decided to further interview the students after having experienced an intervention based upon making the science more understandable. These results suggest that the students now have a better understanding of science and that many of them also like it as well. These results support the raising of the question: Does the nature of science education cause female students' disaffection with science?

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

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PROLOGUE

My Personal background and the Nature of the research

Introduction to the prologue

My own secondary school education began at Harrogate Grammar School, where I successfully passed my examinations. Further, I studied for a Natural Science Degree that I completed in 1990, having studied chemistry, maths and geology.

My interest in teaching began primarily when I started to teach swimming at a local swimming baths. There I taught school aged students swimming for one year, whilst being a lifeguard at the same time. Later I taught English in Greece for a private language school, which gave me an insight into a different culture and a different subject to science. The school was one in which students aged seven to eighteen attended. They attended it in addition to the state schools provided. It was also common for employers to pay their employees to take such educational language courses. Thus, I taught a wide range of students from many different backgrounds whose age ranged approximately from seven to seventy.

On my return to Britain, I undertook a Post Graduate Certificate in Education (PGCE) course at Durham; my subjects were science and chemistry. My two teaching practices took place at Shotton Hall and Staindrop Comprehensive. This qualification enabled me to gain qualified teacher's status for English and Welsh state schools. After completion, I took up position in the Priory school in Kent in Southern England. When my one-year contract finished there, I began my research studies.

Observations from my experience

Whilst learning science at secondary school, I feel that my learning of science took up much more time and was more difficult than that in other areas. However, it was something that I enjoyed, which is why I did it.

There are a number of points that I wish to make about my teaching experiences.

When teaching swimming, students learnt to swim much more quickly once they overcame their fear of the water. In the early stages of their instruction, this overcoming of fear was a major aim in lessons.

The Greek culture was one in which the understanding of a second language, in my experience, was held in a higher regard than in Britain. Many people not only knew a second language, but also were often able to communicate adequately in a third. They also used their language knowledge much more than we do. This ability was shown in that whilst I lived in an industrial Greek town, the majority of the interactions that occurred took place in English rather than Greek.

Whilst on teaching practice during my PGCE course, I experienced two different types of school. Shotton Hall, an ex-mining area, contained students that had a relatively negative attitude towards school and science. In particular, a sex difference had been seen in students' attitudes within lessons. This was noticed by observations made by a number of teachers on specific classes. Boys were seen to dominate the classroom and inhibit girls. To overcome it, sex segregation occurred in years ten and eleven (ages 14 to 16). At Staindrop, a rural farming area, there was a different approach to learning. The science that students learnt

was based upon a highly defined and considered curriculum. This curriculum was extensively described, with descriptions for the science to be learnt for every lesson. It was also based upon what the students actually knew and understood rather that what teachers expected them to know and understand. The teachers there took the time to examine what the students did understand about science and how they might make progress in the subject.

Finally, at the Priory school, students could be described as 'talkative' and learning for them involved a high degree of social interaction. At the General Certificate of Secondary Education level (GCSE) students chose between the sciences single, double, and triple award. Differences were apparent in both the curriculum and the attitudes of the students for each course. For example, those taking the triple award (whose curriculum is the most extensive) seem to have a more positive attitude towards science and occasionally carried on to take science or science related A-levels. Those students that studied the single science award (whose curriculum was less extensive) held a negative attitude towards science, and a great deal of instruction had to be aimed at producing a more positive one.

Conclusion

With regard to my experiences, the attitude of students towards their learning appears to have a high degree of impact upon their learning. Further, in science it would appear that this impact is detrimental in many cases. Part of this impact may possibly be due to the science itself and moreover the curricula, from which students are being instructed. Thus, my research focuses upon students and their experiences with science that may lead them to become disaffected with it.

All the above are merely reflections on reasons as to why I am doing this research. It will hopefully give the reader some insights into any possible biases and prejudices that I may hold and me. Finally, it presents a base upon which to build my research. So I hope to expand and build upon some of the before mentioned reflections. These are my experiences of school and science.

The Nature of the Research

This research was undertaken over a period of four years in total. A major problem occurred in that initially the aims and structure of the research were not clear. The research also involved much thinking, and reflecting. Thus, it was not a case of simply doing the literature review then moving onto the next part of the research. From my point of view it seemed that much of the time, I was going around in circles. Thus, some research literature was considered, then how I could find out more about this from the sample and then a consideration of what it was that I had found out. Following this there would a period of thinking and then I would write down the thoughts. The written down thoughts would then be refined and the circle would continue. During the refinement stages such things were considered, as additional information required, information not required and how to present the information in a structured ordered manner. This refinement process or circular pattern is not seen in this the finished article. Thus, I felt it important to point this out to the reader.

Originally, this research started out to be about sex issues; it was about why female students disliked science more than male students. As the research was refined, sex became less important and other parts of students' dislike became

more important. Further, another strong aspect of science education was found to be lack of understanding of it. Thus, the research developed from sex and science education to something that is very different.

This same sort of refinement process also occurred with the investigation of the B.Ed perceptions of secondary school science. Originally, only one assessment was going to take place. Afterwards it was decided that a more focused second interview would be a good idea.

Chapter 1

INTRODUCTION TO RESEARCH

1 Introduction to the research

The aim to this chapter is to introduce the reader to the research and prepare them for the main arguments that lay within it. This will be achieved through the presentation of two major areas of concern within science education (Gabel, 1994); they are that students hold negative attitudes towards and in science (Kahle & Meece, 1994), and that students do not understand science (White & Gunstone, 1992).

To discuss the vagaries or definition (White, 1993) of the term attitudes is not part of this thesis. The students' negative attitudes will be encompassed by the phrase 'dislike of science'. This dislike of science forms part of the students' disaffection with it. Considering students' choice of subjects to take at 'A' levels will firstly be used to consider whether it is fair to say the students dislike science or not.

The thought lying behind this is that if students do not like science, as opposed to say English, maths or other subjects, then it is probable that students will not opt for it in as greater numbers (Keys & Ormerod, 1976). The choice of 'A' levels is merely due to the importance (Dearing, 1996) of these qualifications within the English and Welsh education systems and the fact that for many of these students

this is the first opportunity that they are given as to whether to take science or not. To suggest that because students tend to take or avoid taking science 'A' levels, they dislike or like science is not entirely satisfactory. There are probably many other possible explanations as to why they choose certain subjects at 'A' level. The consideration of these choices is merely a starting point from which to develop.

1.1 Students' enrolment figures for 'A' levels for the years 1994- 1999

Presented below are figures collected from 'Statistics of Education; Public examinations GCE' published by the DfEE dated from the years 1994 to 1999. The years 1994 to 1999 are chosen in order to give recent results over a reasonable period of time. These are not the only pieces of information available. Others include that supplied by Wilson (1991), which gives a more international perspective. For the purpose of this thesis, the main focus will be upon the DfEE results, as comparison with that presented by Wilson is not easily facilitated due to fundamental differences between countries educational systems.

Table 1 Enrolment figures for all students as a percentage of all in England and Wales for A-levels

England & Wales	1994	1995	1996	1997	1998	1999
subject/ year						
English	12.1	11.4	11.5	12	11.7	11.9
maths	9.7	9.9	10.2	10	9.8	9
Biological Sciences	6.8	7.3	7.3	7.5	7.5	6.8
geography	6.9	7.2	7	6.8	6.8	5.7
chemistry	5.8	6.6	6.1	6	5.9	5.1
history	6.3	6.7	6.5	6.1	5.7	5.1
physics	5.2	5.5	5.1	4.9	4.9	4.4
art & design	4.7	4.5	4.3	4.3	4.5	4.7
french	4.3	4.4	4.3	3.8	3.3	2.7
physical education	0.8	0.7	0.9	1.3	1.6	2.2
music	0.8	0.9	0.9	0.9	0.9	0.9
other	36.6	34.9	35.9	36.5	37.4	41.5
All /total entries	505603	364881	379441	408621	427683	602862

The above table is relevant as it can be seen that the subjects with the most entries are those of English and maths. Other subjects such as biological sciences, chemistry and physics have lower percentages of entries. This might show some indication that specific science subjects are less well liked than other subjects (i.e. English and Maths). Further, the order within the three main sciences (biological sciences, chemistry and physics) is of interest. More students consistently over the six years mentioned take biological science than chemistry than physics. Another aspect of the figures is the change of numbers over time. With biology, no change is seen (6.8%- 1994, 6.8%- 1999). With chemistry, a decrease is seen (5.8%- 1994, 5.1%- 1999). With physics, a decrease is seen (5.2%- 1994, 4.4%- 1999).

A number of pieces of research have been undertaken into enrolment figures for A-levels in the UK. For example, Sears (1993) investigated whether GCSE balanced science had had any effect upon attitudes or A-level uptake. Sear makes a number of statements about enrolment in science A-levels. The main ones are that:

- The main increase in A-level numbers is in biology
- Numbers taking at least one A-level in science are increasing, but the numbers doing only A-level sciences are decreasing.
- The numbers and proportions taking physics A-level have dropped.
- Other statements mentioned relate to the effects of Dual Award science on the uptake of A-levels and the uptake of sciences at University.

Osbourne, Driver and Simon (1998) raise similar concerns. Their main concern is that there is a decline in students studying only science and maths subjects. They are concerned as these are the students who 'are able to pursue further science education and science careers' (Osbourne, Driver and Simon, pp. 28). Thus, there may not be enough scientists to secure the UK's economic future (Dearing, 1996). Further Osbourne, Driver and Simon feel that science educators have failed to communicate the enjoyment, passion and wonder of doing science to possible future science students and scientists (Osbourne, Driver and Simon, pp. 30). In other words, students dislike science. Whitehead (1996) concurs that

a major problem with science A-level choices is the attitudes of the students towards science (Whitehead, pp. 147).

There are limits here as to how much is to be read into these statistics and investigations, as it is possible that students chose to take these subjects due to the low probability of achieving high grades compared with other subjects, or are not accepted onto a science course by the school. In these cases, it would not necessary mean that the student dislikes specific science subjects. Further, it may be that many students who dislike science leave A-level science courses early before they are entered for examination. This dislike of science is much more complex than a set of data presented in the above table and additional evidence needs to be considered to more clearly define this dislike and confirm that students actually do dislike science.

1.2 Science is not understood

The understanding of science is considered an important part of students' experiences of school secondary school science (Driver et al., 1994; White & Gunstone, 1992). This thesis does not probe greatly into what it means to understand science (See White and Gunstone for a more informative in-depth piece of work). A basic definition from which to begin to start to explore this idea is that to gain a basic understanding more is required than simply to be able to read back or memorize words. An ability to apply knowledge to new situations successfully is required (White, 1988, pp. 49).

Within White's book 'Learning Science' (1988), there are a number of works cited that deal with students' understanding of science. Amongst these are Archenhold et al. (1980); Driver (1983); Driver Guesne and Tiberghien (1985); Duit, Jung and von Rhöneck (1985); Helm and Novak (1983); Osborne and Freberg (1985); and West and Pines (1985). This is far from a complete nor conclusive. More recent examples are Gott & Johnson (1999); Johnson (1998); Fensham, Gunstone and White (1994); and White and Gunstone (1992).

White gives a summation of the works cited with regard to understanding:

> *'The studies show that students have well established conceptions that differ from those of scientists and that persist despite the efforts of their teachers' (White, 1988, pp. 77).*

In short, students do not understand science and continue not to do so despite every effort being made by teachers and for that matter educationalists and researchers. What would be of benefit would be to be more specific. Examples of areas (concepts) within science where students' understanding is poor are available. By probing deeper into these areas, it is possible that some reason as to why so little understanding is obtained would be found (White and Gunstone, 1992).

Chapter 2

LITERATURE REVIEW

Students' dislike of science and science not being understood

2 Introduction to the literature review

The aim during this section of the thesis is to provide supportive evidence for the ideas that students' dislike science and that they do not understand it. The evidence for students' disliking science, whilst vast and extensive, is complex in its nature. There are many parts to this disliking and they are interlinked forming what is described as a web. The evidence to support students' lack of understanding of science is much more straightforward. Specific examples of areas within science are available for students' understanding. Further, the analysis within the research is showing the extent within limits of their understanding.

2.1 Evidence to support students disliking science

Key points of interest in the students dislike of science are that science is said; to be sex biased (Kahle, 1990; Kelly, 1987; Smail, 1984; and Solomon, 1994), to be irrelevant (Ziman, 1980, and 1994), to have a poor image (Kahle & Meece, 1994; Kelly, 1987; and Monhardt, Tilloson & Veronesi 1999), to be culturally biased (Jegede, 1994; Jegede & Fraser, 1989; Jegede & Okebukola, 1989, 1990, 1991, and 1993; and Okebukola & Jegede, 1990), and to be for academics (Aikenhead, 1996; Berryman, 1983; Chubin, 1990; Costa, 1993; Krieger, 1990; and Lee, 1987).

Further, this is an attitude held by students and to some extent teachers, which may or may not be the case in actual reality. These attitudes result in peer group pressures (Byrne, 1993; Cullingford & Morrison, 1997; Guzetti & Williams, 1996a, and b; and Winiarski-Jones, 1988) and teacher expectations (Boyes, Chambers & Stainistreet, 1995; Eccles & Wigfield, 1985; and Kahle, 1990; and Kenealy et al., 1991), which not only is part of students' dislike of science, but also help develop it further. In addition to these aspects of students' dislike of science, there is also the effect of the media upon students and parental influences (part of which is public understanding of science). These topics have only really been touched upon in this thesis. For the interested reader I would like to suggest the following references, which may be fruitful should further investigation be required. The references are Durent, Evans & Thomas (1989); Furnham (1992); Jasanoff, Markel, Peterson & Pinch (1994); Layton, Davey & Jenkins (1986); Parsons, Adler & Kaizala (1982); Prewitt (1983); Reiss (1993); Turner (1991); Van de Brul (1995); Van Deelen (1990); Wilkie (1991); and Zaller (1992).

2.1.1 Students dislike Science as it has a perceived sex bias

The statement that students dislike science as it has a perceived sex biased is one that has been extensively explored within science education. This is shown by the vast amount of literature available on the topic (e.g. Kahle, 1990; Kelly, 1987; Smail, 1984; and Solomon, 1994). One way of showing this bias is through a deficit model (Solomon, 1994). Stated simply this means that when given the choice more girls than boys choose to drop science. By expanding and focusing upon the table of subjects taken for 'A' levels, we may be able to see this. By

expanding, I mean looking at the choices in terms of that made by boy and girls. Further, I mean to focus upon the three key science subjects those of biological sciences, chemistry and physics.

Table 2 enrolment figures for all males and females for A-levels

subject/ year	1994		1995		1996		1997		1998		1999	
	m	f	m	f	m	f	m	f	m	f	m	f
biological sciences	18091	27997	14172	21898	11465	16070	20890	30587	21075	31185	19620	30539
chemistry	21109	15834	17453	13205	13328	9936	21258	16993	20962	17790	19830	17639
physics	25401	6988	20349	5407	15225	4126	23442	6402	23809	6796	23502	6926
totals	64601	50819	51974	40510	40018	30132	65590	53982	65846	55771	62952	55104

What is seen when this is done, is that for every year the totals of male students exceed those of the female students. Further, in chemistry and physics the male entries outweigh the female entries. Thus, there is a female deficit.

However, the situation is not so clear when it comes to individual subjects. For example in all years in biological sciences, the female entries exceed the male entries. Further, it is not clear whether females choose not to study science (relative to males), or whether males choose to study it (relative to females). Moreover, one might argue that even when both male and female students are totalled and compared with other subjects the choice to take specific subjects is still (comparatively) low and thus independent of sex.

Work by Kelly (1987) explores this subject as a female deficit model. This is that girls are said to dislike science more than boys. The masculinity of science is seen in various studies into students' attitudes in science. In general, these and other studies suggest that boys in science have a more positive attitude than girls (Baker, 1997; Gardener, 1975; Kelly, 1987; Kahle & Meece, 1994; Simpson and Oliver, 1990; and Weinburg, 1995). For example in Simpson and Oliver, 4000 students' attitudes were studied whilst in secondary school. In this study, boys were found to hold more positive attitudes in science than girls. Further Baker's study found that girls held more negative attitudes than boys.

To say that all science is masculine though is an over simplification. In Weinburg's meta-analysis of students' attitudes towards science, biology is shown to be less masculine than physics and general science. To some extent this may explain why in the enrolment figures given above, more girls study biology than physics.

Solomon (Solomon, 1994) presents additional ideas as to what female and male students like to occur in the classroom. The suggestion is made that boys opting to study science is not only to do with them liking science, but with the type of lessons that occur in science (Solomon, pp. 144). Thus, male students choose to study science, as these school lessons are male dominated and authoritarian in nature (Solomon, pp. 144). Solomon suggests that if lessons were more social and applied in nature that science would be more liked (by females). This suggestion is based upon research by Head & Ramsden (1990); Collins & Smithers (1984); Grant (1987); and Murphy (1990).

Work by Grant (Grant, 1987), and Murphy (Murphy, 1990) focuses upon students' response to two types of question. Girls are said to be unwilling to respond to questions requiring a positive or negative answer, preferring instead questions with answers that contained uncertainties and a number of possibilities. These questions tend to be more applied and social in nature. Boys on the other hand like questions that have short answers and limited possibilities. Murphy suggested that secondary school science may contain

more of these boy-preferred questions which is one reason why boys like school science and girls do not.

Therefore, school science is sex biased as more boys choose to study science than girls. This is because boys find school science 'reassuringly male and authoritarian' (Solomon, 1994, pp. 144). Further girls dislike school science due to the male dominated, authoritarian lessons. Further, they see science as being unsocial and not applicable to their lives. Thus, girls also choose not to study it.

2.1.2 Students dislike science as it is perceived to be irrelevant

Students find science education to be irrelevant (Ziman, 1980, and 1994). One particular attitude that is said to be particularly disparaging is that science that is taught in schools needs to be universal and that this is achieved by making science the same throughout the world. Thus, Ziman is suggesting that science in schools is too uniform. Further, this science is uniformly irrelevant. Therefore, a uniform part of students' dislike of science is that it is irrelevant.

A major weakness of this science irrelevance is:

> *'.. not what it says about the world, but what it leaves unsaid' (Ziman, 1994, pp. 22)*

To say more about the world and in particular the world of the secondary school student new approaches and ways to teaching science need to be considered.

In saying that science needs to be different in the way it is taught, there is a problem. When all these different methods of teaching science are considered there are conflicting results.

For example, one method of teaching science that is often suggested to improve attitudes is the use of science practicals (Kok-Aun, 1993). This is different to the 'standard' science where students take notes and copy from the blackboard. In practicals the students use 'scientific equipment' (Bunsen burners, beakers, weights, rubber bands and so no) to perform scientific experiments (investigating the combustion of gases, the heating of water, stretch in rubber and so on). There are also those that suggest there are a number of difficulties that occur (Tobin, Kahle & Fraser, 1990; and Woolnough, 1991). These difficulties include the teacher adapting to a different style of classroom management. The students are organised into many groups rather than a whole class. Further, there is a need to organise school science equipment and be aware of safety issues with regard to its use. Additionally whilst the use of school science equipment by students may make lessons more enjoyable, there is the risk of them losing sight of the underlying scientific principles (Tobin, Kahle & Fraser, 1990). In Tobin, Kahle and Fraser, one of the teachers observed took this practical approach to learning. This particular teacher had a problem with managing one class involved in that some students behaved in a manner that was unacceptable in a classroom. Thus, the teacher had to constantly be aware of this and take actions to curb these particular students' behaviour, which prevented her

from effectively enabling the students to learn (Tobin, Kahle & Fraser, pp. 80).

Another example is the use of discussion within science classrooms. One standard way of teaching is for the teacher standing and talking to the class from the front whilst the students listen (Tobin, Kahle & Fraser, 1990). An alternative is for the teacher and class, groups within the class and individuals to take it in turns to ask questions, answer questions, and listen to what is being said (Guzzetti & Williams, 1996b). With the first method all the class get to hear the same thing (Tobin, Kahle & Fraser, 1990). However, they do not get to ask questions or put forward their own ideas (Tobin, Kahle & Fraser, 1990). In the latter case, often students do not play equal parts in the discussion and certain students will benefit more from the discussion than others (Guzzetti & Williams, 1996a, and b; and Tobin, Kahle & Fraser, 1990). In Tobin, Kahle and Fraser a second observed teacher uses this whole class teaching method, where the teacher talks and the students listen and copy down what is being said (Tobin, Kahle & Fraser, pp. 70).

For the examples given, there are conflicting results. What Ziman is saying is that whilst these methods do not work in all cases, they do in certain ones. Therefore, they are worth considering. Further rather than considering these ideas as detracting from the standard science, they should be considered as additional possibilities.

An additional point is that whilst these results may appear to be conflicting there may be an underlying consensus. Therefore, from the two main examples given above; practicals may involve some discussion, and discussion may involve practicalities. Further, both examples are trying to bridge the gap between real life and science.

Ziman suggests a number of approaches that may be able to make science more relevant and so bridge the gaps between real life and science. The way science is taught is irrelevant to students' experiences of life outside school, to other subjects within school and to problems that occur in life in general.

The way science is taught is irrelevant to students' experiences of life outside school, as many limitations and simplifications have to be made so that real life situations can be explained. Ziman gives the example of elephants being spherical, ladders being weightless and walls being perfectly smooth. Further, a more obvious point is that the whole context of the science is wrong. In other words, real life for most students is not about elephants, ladders or walls. A further view is that the context in which the science is being taught may be stereotypical. Thus, students are classed into scientists or non-scientists (referred to by Snow (1993) as artists). Within his works, Snow gives an example of this break down into two major sets of subjects (those of the arts and the sciences).

The situation is a formal academic dinner where a number of students are placed around the table. As the dinner progressed, Snow noticed that certain people only talked to certain other people. The underlying rule for this is situation appeared to be that scientists only talk to scientists and artists only talk to artists.

Thus, students who study science are interested in certain aspects of real life and these aspects are those covered in science lessons. Saying that those non-scientists are interested in different aspects of real life, which are not covered in science lessons, complements this.

A part of this not relating to real life occurs within secondary school, in that science is not relevant to other subjects within school. This problem is also prominent within the science. Science subjects in school are often broken up into physics, chemistry, biology and other subjects. Ziman gives an example of a stone being described in three different science lessons (in physics, chemistry and geology). Rather than three different descriptions of a stone being presented to the student, the student should be aware that all these different descriptions are interrelated and at certain points, different descriptions are more convenient. So given that it is a problem between science subjects, it is not surprising that links between science and other subjects do not occur.

Ziman makes note of a weak link between science and history amongst possible others. Another weak link is between science and English (Tobias,

1993; and Wellington, 2000). Within the historical links, Ziman draws upon the argument that science is original. In other words, science seeks to create new and improved ideas and ways of living. Further, the development and improvement of science over time, is therefore an important part of the science itself. Thus, there are links between science and history. Strong historical episodes within science history appear to be; the trial of Galileo for his interpretation of the motion of the planets, the debate of 'The Origin of the species' presented by Darwin, Marie Curie's investigation into radioactivity, and James Watson's idea of the Double Helix. These would be episodes from which it should possible for students to gain (Ziman, 1994). In addition to those ideas mentioned above Boeha (1990), uses Aristotle to present science ideas to students in Papua New Guinea.

Ziman suggests two major reasons why science lessons do not exploit these links more fully. They are that science history is extremely complex and that secondly elementary science history is not complete in that it is impossible to present outmoded ideas and failures in science to the student. This is due to the overly optimistic stance taken with this type of history.

Much of science involves the use of language in a specific and unusual manner. For example the use of the word 'element' is specific in chemistry and does not relate to light bulbs. Further, the idea of a living organism is highly defined in science whereas in English, flames may be said to be living. A second point is the strong association of science with numbers and long complicated formulae as opposed to written explanations.

In neglecting the link between English and science, students have difficulties relating to the complex scientific vocabulary (Marshall Gilmour & Lewis, 1991; Pickersgill & Lock, 1991; and Wellington, 2000, chapter 9, pp. 166-192). Wellington (Wellington, 2000, chapter 9) explores this area giving advice to trainee teachers with regard to students' learning in science.

A comparison is made between entering a science laboratory and a strange world (see later section 2.1.5). When entering this strange world, strange devices such as Bunsen burners, evaporating dishes, beakers and conical flasks are encountered. These are all objects with strange names. Names not heard of before entering the science laboratory. Further, as students begin to learn science additional complexities in language occur. For example, Wellington (Wellington, 2000, pp. 168) describes three other categories. One example is that of process words (amongst the others). Examples of process words include 'evaporation', 'combustion', and 'evolution'. The process language involved is becoming more abstract. Thus with naming words the object can be pointed out and named. This is not so easily done with processes. Thus with 'evaporation', a demonstration may be performed with water being boiled. To fully grasp the meaning the word 'evaporation' the student has to grasp abstract models, an example of which is particle theory.

It is not surprising that whilst some students will be curious and interested in this new 'science language', others will see it as a barrier (Wellington, 2000). Within work by Jedege (see later section 2.1.5) an example is given of an African farmer not knowing what the word ecology means, yet still have

knowledge and understanding of animals and plants, and relationships between them and the place in which they live. In this manner, language acts as a barrier in science lessons. This barrier may form some of the students' dislike for science.

2.1.3 Students dislike science as it has a poor image

One part of students' dislike of science, is the image held by themselves of scientists (Kahle & Meece, 1994; Kelly, 1987; and Monhardt, Tilloson & Veronesi, 1999). The image students have of scientists has extensively been explored through the 'draw - a - scientist- test' (Monhardt, Tilloson & Veronesi, 1999). These tests have been developed since the 1950s by such researchers as Mead (e.g. Mead & Metraux, 1957), Chambers (e.g. Chambers, 1983), Mason (e.g. Mason et al., 1991), Huber (e.g. Huber & Burton, 1995), and Finson (e.g. Finson et al, 1995). In the draw-a-scientist-test, the students are requested simply to draw an image of what they think a scientist looks like. The results from these pieces of research are similar. The majority of studies can be summarised (Newton & Newton, 1998) in that students see scientists as being:

> *Male, balding, bespectacled and with a laboratory coat, working alone in a chemistry laboratory environment.*

The above quotation is taken from work by Newton & Newton (Newton & Newton, 1998). In this work they were exploring whether the National Curriculum had had any positive effect upon the image students had of

scientists. The results suggest that the National Curriculum in the UK has not had a positive effect upon students' images of scientists.

Whilst the study above involved primary school students aged 6 and 11 years of age, similar results have been obtained with older students (Song & Kim, 1999). Schibeci (Schibeci, 1986) is reported by Song & Kim as having made the following comments about it.

> *It is rather discouraging that the images of scientists are generally unfavourable and negative regardless of students' level of schooling*

Song & Kim (1999) in their research investigated students aged 11, 13 and 15 who came from Korea. The results from this study suggest that for the students investigated, similar images were held to those of comparable students in other countries.

An interesting aspect of these studies is that these studies concern students' perceptions. It is interesting to look at actual scientists and see how they actually perceive themselves. Work by Monhardt, Tilloson & Veronesi (1999) involves the interviewing of 18 people from both academic and industrial research settings. Two major factors amongst others were examined: that of becoming a scientist and that of living within a scientific community.

When considering becoming a scientist many of those interviewed did not study science extensively in secondary education. Further, they did not decide to pursue a career in science at school. Other factors that influenced their

choice of career were their family background. Some of the scientists suggested that activities undertaken as a child with the family did influence their choice. For example, one scientist says that she often went bird watching with her parents and that this gave her an interest in science. Another perhaps more stronger factor was that of mentors. This encouragement and support was described as being:

> *A very positive aspect in influencing the career choices made (Monhardt, Tilloson & Veronesi, 1999, pp. 539).*

This is also supported in Aikenhead (Aikenhead, 1996, pp. 12), whose work is later mentioned (2.1.4).

The final aspect that was talked about was a barrier preventing people from becoming scientists. Within this section there were three major barriers mentioned. They were; the actual coursework and challenge of then finding a position, the balancing of family life with a career and the low pay attributed to being a scientist. These factors appeared to be stronger for the women interviewed than the men (Monhardt, Tilloson & Veronesi, 1999).

Further when talking about living in a scientific community, a number of traits were described for scientists. The main traits were objectivity, ego, intuition, problem solvers, and being caring (Monhardt, Tilloson & Veronesi, 1999).

Objectivity is said to be difficult to obtain with many scientists not being aware of their own biases. Further, the seeking of objectivity is likened to 'religious devotion'. It is something that is strive for and yet almost impossible to obtain.

A major problem to objectivity is a person's ego. This clouds judgement and some scientists feel that they are able to make statements that will be accepted without question and the need to provide supporting evidence.

A third trait was that of intuition. Intuition is the ability to come to a correct conclusion without knowing exactly how the conclusion was reached. An example is given. One scientist states that she is able to identify a rock sample from a distance, when others require a microscope.

Problem solving was also said to be an important trait. Scientists explore questions. They break questions into smaller parts. They examine these parts and the put the part back together to find a final answer. Another example is taking a problem trying out a number of possible answers and rejecting those that do not work. This work does require some patience and some dedication (Monhardt, Tilloson & Veronesi, 1999).

Finally, there is the trait of being caring. Many of the scientists saw their work as being a service. Much of the reward they felt was obtained from knowing that their work was helpful to other people. One interesting point was made in that one scientist who said that scientists were portrayed as being uncaring. An example was made of an intervention that was to be applied to students

based around being able to be scientist and still be caring (bibliographic references to the intervention were not made). The scientist, being interviewed, felt that this implied the scientists were uncaring (Monhardt, Tilloson & Veronesi, 1999).

A comparison made between the image presented by students and scientists is difficult. Perhaps to present a scientist in the form of a picture is an over simplification of what it is to be a scientist. When talking to scientists, science is more than simply working in a laboratory. Further, many of the scientists whilst mentioning that science is difficult and requires dedication, hold some positive views of science. Some of these scientists feel that students are not being allowed to see these positive views (Monhardt, Tilloson & Veronesi, 1999).

Thus, students see a poor image of science. They have a poor image in that it is a negative image (Newton & Newton, 1998; and Song & Kim, 1999) and an image of service with little monetary reward (Monhardt, Tilloson & Veronesi, 1999). Further, the image is perhaps not a true reflection of what it is to be a scientist (Monhardt, Tilloson & Veronesi, 1999). This image relates the students like or dislike of science (Monhardt, Tilloson & Veronesi, 1999). Therefore, the poor image of scientists is part of their dislike of science.

2.1.4 Students dislike science as it is an academic subject

Science education has been described as being academic. In other words people start learning science in primary school and finally become a scientist

after taking a degree at University. Thus, policy-makers see science education as a 'pipeline' through which students pass on their way to becoming scientists (Aikenhead, 1996; Berryman, 1983; Chubin, 1990; Costa, 1993; Krieger, 1990; and Lee, 1987).

So to get a reasonable understanding of science lengthy and sustained learning is required, which many students may not like. Further, within the pipe there are stages. Thus within England and Wales there are science GCSEs followed by A levels, degrees and postgraduate degrees. At each stage, a refinement of the students takes place. Thus, students must gain acceptable GCSE results to progress onto A levels and so on with A levels, degrees and postgraduate degrees. Thus at each stage 'leakage' occurs. That is students are lost from the pipeline. Finally, the talent emerges at the end to become finished scientists (Aikenhead, 1996; Berryman, 1983; Chubin, 1990; Costa, 1993; Krieger, 1990; and Lee, 1987).

To increase the talent two changes are required. The initial number of students entering the pipeline is increased, or the leakage from the pipeline is reduced. In England and Wales, both of these tactics have been employed by policy makers to increase number of scientists. For example, with the introduction of the National Curriculum in 1989, all students were taught science in all state primary schools and secondary schools (increasing initial numbers). Further, the learning of science was made compulsory up to the age of fifteen (reducing leakage). The effectiveness of these measures and of

the 'pipeline' model is debateable (Costa, 1993; and Aikenhead, 1996). Costa (Costa, 1993) points out a flaw in the pipeline model saying that:

> *[T]he school science-as-a-pipeline ignores teacher and student meaning-making. (Costa, pp. 650)*

Thus, the pipeline model is an institutional model, which does not get to the real problem. The real problem (at least in part) is in the classrooms. To get to this part of the problem there is a need to consider the perceptions of teachers and students. Once this is undertaken, some understanding of why students do not choose to or decline to learn science might be obtained. Further it may be that teachers are not offering students the opportunity to learn science. Thus, there is a need to obtain 'teacher and student meaning-making' (Costa, 1993).

To take into consideration the perceptions of the teacher and the student Costa suggests an alternative:

> *One such alternative would be to characterize school science as a rite of passage into the scientific community. (Costa, pp. 650)*

The aim of this metaphor is two fold. Firstly, the metaphor is to take into consideration the perceptions of teachers and students in the science classroom. Secondly, it is to shift the emphasis away from attracting and retaining students towards a curriculum that is progressive (Costa, 1993).

Costa explores this metaphor by collecting data from 300 students enrolled in a chemistry course in a major California University. The data is collected through making observations of those participating in the classroom activities. Using this data and the metaphor, the problems students have with science are noted. There are three major parts to the 'rite of passage'. They are: separation, transition, and reincorporation (Costa, 1993).

Separation is where students are removed from their normal environments and placed into a science-based environment. In simple terms, this may mean going into a school science laboratory (Wellington, 2000). On a longer-term basis, this separation is from other occupations into the position of scientist. Within Costa's data, this part is shown in a difference made by University lecturers between school science and University science (Costa, 1993).

The transition period is when the student lies between non-scientist and scientist. So this is when the student is 'learning'. Thus, it is when the student is performing experiments, doing homework and thinking about problems. Costa suggests that this stage is shown in their attitudes in science as well as their actual activities (Costa, 1993).

Reincorporation is going back into a more normal environment. That is leaving the school science laboratory, having learnt something about science. Costa notes this reincorporation as being the holidays between terms, when students return home (Costa, 1993).

To present the 'rite of passage' as simply one separation, one transition, one reincorporation is an over simplification. It is rather a series of separations, transitions and reincorporations (Costa, 1993). For example in the English and Welsh state school system there are GCSEs, A levels and degrees in science. Within each of these, there are parts that might be described as being separations, transitions and reincorporations. Thus for example with GCSEs separation is going into a school science laboratory, transition is learning GCSE science and reincorporation is going back to interacting with other students after the science lesson. With A level science there are likely to be differences in where they learn, what they learn, and those students with whom they interact. Even so there are likely to be similar periods, which can be described as being separation, transition and reincorporation (i.e. going to the A level science laboratory, learning A-level science, and returning to the A-level students common room).

Further there may be differences of scale. For example, Costa notes that that there are elements of separation, transition and reincorporation within specific separations transitions and reincorporations. Thus within science lectures (described above as a transition stage); there is separation in that the lecturer points out differences between science being learnt now and before (University science is different from school science), there is transition in that the lecturer is presenting scientific ideas and theories to the students (using a blackboard or projector), and there is reincorporation in that demonstrations are seen as a break by a lecturer (from science). So at any one time a number

of series of separations transitions and reincorporations may be occurring to the students (Costa, 1993).

When students experience these parts of science, there are difficulties. These difficulties might explain why students do not choose to continue to study science when given the option to stay or leave.

For example within the separation part, students may not be aware of the goals of the separation. In other words, students may not be aware that they are being developed into scientists. Further, there may be many goals to this separation. I.e. the goals may be to develop scientists or to develop a scientifically literate population amongst others. Even if students are aware of the goals, they may not like them (not everyone wants to be a scientist or scientifically literate). Thus, these difficulties may be part of students disliking science.

In the transition part students are expected to cope with duality. That is being a scientist and a non-scientist both at once. Further, in changing from one to another it may be that the student likes being a non-scientist. So as the transition progresses and the student becomes less and less of a non-scientist the dislike increases. This dislike may or may not be outweighed by the students like of progressing towards being a scientist.

Finally, in the reincorporation part the student has now to cope with being more scientific than others in the population. This coping involves the

dealing with popular negative attitudes towards science and scientists. Science students may again dislike this.

Thus, science is seen as an academic subject. Science education is described as a pipeline for producing academically qualified scientists (Aikenhead, 1996; Berryman, 1983; Chubin, 1990; Costa, 1993; Krieger, 1990; and Lee, 1987). This 'model' of science education does not take into account the feelings of students (Costa, 1993; and Aikenhead, 1996). The 'science as a rite of passage' metaphor does (Costa, 1993). This metaphor identifies some of dislike students have of science.

2.1.5 Students dislike science as it has a perceived cultural bias

The UK may possibly be described as being made up of a number of groups of people with varying cultures. For example, there are groups of Africans, Indians, English, Scottish, Irish, and Welsh people amongst others. To some extent, these groups of people have their own cultures (Jegede, 1994). Jegede's work (Jegede & Fraser, 1989; Jegede & Okebukola, 1989, 1990, 1991, and 1993; and Okebukola & Jegede, 1990) focuses upon a comparison to some extent between African and Western culture with respect to learning science in school classrooms. To some extent, the idea of a culture is comparable with a group of customs (Cobern, 1991; and Phelen, Davidson & Cao, 1991).

In Jedege (1994), it is stated that:

> *...[C]ustoms that the learner brings into the classroom are in opposition to, or incompatible with modern science. (This leads to misconceptions, negative attitudes toward the study of science, and.....).*

Jedega links these incompatibilities in customs to negative attitudes. So to some extent these incompatibilities may be part of students' dislike of science.

Within his work, a number of major African customs that are incompatible with modern science are noted. They are: 'authoritarianism', 'goal structure', 'traditional worldview', and 'sacredness of science'.

'Authoritarianism' is the custom of seeing older people as being more knowledgeable than younger. This is because they have more experience of life. Younger people do not question an elder's point of view, but rather accept it. Within the science classroom, this would translate to a dominant teacher who knew everything about science. This may be part of the dislike of science in that students may be expected to question commonly held views.

'Goal structure' is a custom of cooperating with other members towards a major goal accepted by all. In the science classroom, students may be required to be individualistic and competitive. Therefore, students may dislike science.

'Traditional worldview' is a custom that relates to superstitions and an interpretation of occurrences in terms of these superstitions. Thus, a younger person may believe in these superstitions, which are in opposition to scientific knowledge and the scientific point of view. So again, students may dislike science.

'Sacredness of science' is the custom that science is special, almost magical, in nature. Thus to study science and school, there is a need to produce magical explanations that cannot be produced by the vast majority of students. Thus again students dislike science.

Aikenhead (Aikenhead, 1996) takes this idea that western science is part of a culture and as such is different from African culture and other cultures (Maddock, 1981; Knamiller, 1984; George & Glasgow, 1988; Swift 1992; Hodson, 1993; and Jegede, 1994). Further, the idea is added to, by considering school science as being a type of culture. Moreover, it is applied to school science and students with differing backgrounds (i.e. coming from different cultures). To do this there is a need to understand that school science has customs that make it a type of culture. Already within the previous sections, some of these customs have been noted. They are that science is: masculine, irrelevant, and has a poor image (2.1.1, 2.1.2, 2.1.3.). Aikenhead (Aikenhead, 1996) describes this type of culture as being a subculture as it is a culture within a culture (i.e. school science is part of western culture).

Cultural backgrounds are seen as being of importance within the science classroom as they explain 'how students make sense of their natural world' (Aikenhead, 1996, pp. 3). This is also to some extent an aim of school science, (i.e. to make sense of the natural world). Thus, school science is seen as being a transmission of a culture to a student. This transmission is either 'supportive or disruptive' (Aikenhead, 1996, pp. 5; Baker & Taylor, 1995; and Urevbu, 1987). In other words, students like or dislike this transmission.

Aikenhead reports on this like or dislike of science in terms of five main groups developed by Costa (Costa, 1995). Costa (Costa, 1995) developed groups using qualitative interviews with secondary school students. The students numbered 43 and came from two culturally diverse schools. Further, the students were all taking science subjects at school. The groups will briefly be described in appropriate terms related to those used in this thesis. The five groups are named: 'Potential Scientists', 'Other Smart kids', "I don't know' students', 'Outsiders', and 'Inside Outsiders'. For this thesis, as will be seen later (section 4.1), the two major groups of interest are those of 'Potential Scientists' and 'Other Smart Kids'.

Potential Scientists like science. They do not mind the stereotypical image of science presented of those who study science. Further, they have family and friends who hold positions within science or study science. These people act as role models for them (see 2.1.3). They overlook poor experiences of science experienced in school science lessons. They consider science to be an important part of their life and wish to take science 'A' levels. Further, they

are likely to have science career aspirations and are likely to be white males. There are relatively few students found to fit into this group.

'Other Smart kids' like school. They may also feel fine about the image of those who study science. They do not like the actual science. They study science as a means to an end. It may be that to progress onto further education they have to pass science examinations. Thus, they will attend and pass compulsory science classes to achieve this progression. This may be achieved through memorizing important science facts. They see themselves as being creative and artistic, which is not how they perceive science. They escape from science as soon as possible preferring those subjects they feel to be more artistic in nature. Their friends and family may be educated to a high level and want to progress within education. They are probably not directly involved with science. More students fit into this group than 'Potential scientists'.

"I don't know' Students' are students who frequently give ubiquitous responses to questions related to science. They are noncommittal. In many ways, they see school science lessons as being a game. Rather than learning about science, they learn how to successfully pass examinations. They feel good about science lessons and continue to do so as long as they are not expected to replace their thoughts with those expressed by the teacher and materials presented within the classroom. These students know little of what science is and see teachers as being all-knowing.

'Outsiders' are students who don't feel part of school or science lessons. They feel alienated and incompetent. Science and school is not part of their family life and they do not have friends within school. They have little contact with the other people in their science lessons. Further, they have no understanding of science and what it is to be learn science and they do not care. They see the teacher as being an expert and authoritarian figure.

'Inside Outsiders' are students who have some idea of what science is. They are interested in science. They do not though take an active role within lessons at school. They raise science related questions. They do not raise these questions within school science lessons.

In considering these groups, four out of five of the groups experience some difficulty with the subculture of school science. Thus for many students the transmission of this culture is not smooth. Aikenhead (Aikenhead, 1996) describes 'assimilation' as a common way in which these students are expected to come to terms with this culture. For many students this is neither effective nor acceptable. It is disruptive. Thus, many students will probably dislike science.

2.1.6 Students dislike science due to pressures not to learn science applied by peers, and teachers

As well as the reasons given above for students disliking science, there is a need to consider more direct methods through which students are turned off science. In simple terms, this involves a person in authority telling the student not to learn science. In more complex terms less direct peer

pressures, such as teacher and expectations are placed upon many students not to learn science.

Cullingford and Morrison investigate peer pressure (Cullingford & Morrison, 1997). The study focuses upon interviewing 25 students who have been excluded from school. Cullingford and Morrison say that:

> *Peer groups, then, are an inevitable and significant influence in attitudes (Cullingford & Morrison, pp. 63)*

Peer groups are defined in terms of perceptions of their own identities. The groups are formed to resolve potential problems and actual conflicts that arise in school playgrounds.

Winiarski-Jones (Winiarski-Jones, 1988) explores peer groups within the school classroom. The peer groups are said to form as a result of students wanting to find similar persons that they 'like' and to whom they are able to justify their actions. Further once groups are formed changes in attitude occur. Thus if a student joins a peer group that dislikes science then the joining student may also begin to dislike science too. Winiarski-Jones uses the example of academic performance. The suggestion made is that peer pressure effects students learning. So if a goal for a peer group is to learn (or not to learn it), then each member of the group will try to learn to justify continued participation in the peer group.

Byrne (Byrne, 1993) looks at peer pressure within school science. An idea called the 'Snark syndrome' is developed. The 'Snark Syndrome' is the saying of the same thing repeatedly. If this is said to by influential people to other people in a group then those other people may believe what is being said whether there is any evidence to support it or not. In science, one example is that students are told not to study science (Byrne, 1993). Many people tell them this and so students hear it many times. Thus, students choose not to study science. This to some extent occurs within peer groups, so peer pressure exists to prevent students from studying science.

Byrne (Byrne, 1993) develops this peer pressure in terms of what she describes as 'critical mass'. The mass is described in terms of numbers taking science. If these numbers are low (comparatively to other subjects) then the peer pressure will be towards not choosing to take science. These pressures will result in a decrease in numbers taking science. It can be seen that this is a downward spiral. As numbers of students taking science are low, a negative pressure exists to reduce the numbers further. So numbers of students taking science are now lower and so the downward spiral continues. If by some means, the number of students taking science is increased to a specific number (i.e. critical), then the pressure to study science is neither negative nor positive. That is students are told both to take science and not take science in such a way so as to not create any pressure. This results in the numbers of students taking science remaining static (at least in an idea system, which this is not).

Finally, there are specific examples of negative peer pressure taking place within a school science classroom. Two of these examples are given below. Kahle (1990) and Guzetti & Williams (1996a, b) report on students pressurising other students in science practical classes and discussions.

Kahle points out the following example. The example is taken from 'Windows into science classrooms', in which two teachers and classes are observed over several weeks. During these weeks, two topics were observed. They were 'Vertebrates' and 'Nuclear Fuels'. In both these units, it was observed that groups of students 'monopolised' school science equipment and further actively prevented other groups from participating in the science activities. In the nuclear fuel unit, students achieved this by destroying and contaminating experimental materials.

Guzzetti & Williams (Guzetti & Williams, 1996a, and b) undertook research into discussions taking place in physics classrooms over a period of two years. The research involved observing, applying a questionnaire and interviewing a number of students. One finding pointed to peer groups applying pressures on other peer groups to act in a certain way. For example, within discussions when students were divided into small groups (typically around 5 people) certain students were pressured into presenting the findings of the whole group rather than others. In Guzzetti and William's research, females were pressuring males to do this.

As well as pressures within peer groups and between peer groups, there are also teacher expectations. Teachers are said (Boyes, Chambers & Stainistreet, 1995) to affect how students learn science. For example, Boyes, Chambers and Stainistreet look into the ideas that trainee students hold about the Ozone layer. The findings are that many of the trainee teachers hold limited knowledge and erroneous knowledge in this area. With regard to these findings Boyes, Chambers and Stainistreet say that:

> *These findings have particular relevance in the case of trainee teachers who will be in a position to influence the ideas and attitudes of many generations of children. (Boyes, Chambers and Stainistreet, 1995, pp. 144)*

Thus, the trainee students will become active teachers. As active teachers, they will influence whether students like or dislike science.

This idea of influence by teachers is taken further to expectations. In the classroom, teachers have expectations (Eccles & Wigfield, 1985; and Kahle 1990). These expectations concern how the teacher sees students' learning developing. These expectations are said to effect how students develop academically (Eccles & Wigfield, 1985; Kahle, 1990; and Kenealy et al., 1991). Thus to some extent if a teacher sees a student as not being good at science, then that student is to some extent likely to become not good at science (Kenealy et al., 1991).

Teachers expectations were also observed by Kahle (Kahle, 1990) in an investigation of two teachers and their interactions with students in the classroom. One teacher is named 'Peter'. One way that Peter teaches is by asking the whole class questions and responding to students who raise their hands. In these whole class discussions, certain students tend to be chosen to answer questions more than others. Further, certain students also tend to put up their hands more than others (Kahle, 1990, pp. 126). The implication is that Peter is expecting certain students to put up their hands, and to some extent this is what is occurring. Further, on a secondary level in personal one-on-one interactions occurring between the teacher and students were not expected to respond in an 'academic or scientific' manner. This was shown in the questions asked by Peter to the students in these situations and his response to questions asked by researchers (Kahle, pp. 126).

Whether teachers are aware of these expectations being put across in the classroom or not, is not clear. The researchers suggest that students to some extent are aware of them and respond to them (Kenealy et al., 1991). Further, these expectations are that only certain students should participate in science lessons and that others should not. In case of Peter, those that participated actively in science lessons were few.

It is therefore possible that many students in Peter's class feel that they should not participate in science lessons. Problems may occur with students who want to actively participate in science lessons but are not expected to. These

students may dislike science. If this situation is applicable to school science classrooms in general it may be part of some students dislike of science.

The above work by Kahle (1990) has similarities to that presented by Jones & Wheatley (1990). Jones & Wheatley investigated the way that teachers expressed their expectations to students. Observations were made of 60 classes and some 50 teachers. The expression is defined in terms of: praise given to students, teacher response to call outs by students, warnings given by teachers, and procedural and direct questions given by teachers. Jones & Wheatley conclude that these expressions may detrimentally effect course enrolment and motivation for certain students. In other words, these expressions may be part of students' dislike of science. This second research involved many more teachers than that of Kahle (1990). Thus, it suggests that this situation is applicable to science classrooms on a more general level.

In interesting point is made by Jones and Wheatly (1990) in their research. From the findings, it was not certain the expressions mentioned above were actual expressions of teacher expectations, or of peer pressures. The peer pressures of students as commented upon by Cullingford & Morrison (1997) point to these pressures being separate from the adult world. Thus, it is difficult to say if peer pressures result (to some extent) in teacher expectations or teacher expectations result in peer pressures, or if both these situations occur, or if neither of these situations occur. Jones & Wheatly suggest that students come to the classroom with experiences from outside the classroom and that these experiences affect the way that they act in the classroom.

2.2 Evidence to support science not being understood by students

During this section the aim is to review specific areas of science and examine what research has to say about the understanding in these areas by students. Those to be noted are understanding of gravity, understanding of forces, understanding of particle theory, understanding of combustion, understanding of the skeleton and understanding of animals. These are not the only areas in which understanding by students has been investigated. A starting point for other areas is work by Driver, Squires, Rushworth & Wood-Robinson (1994); Osbourne & Freyburg (1983); Driver, Guesne & Tiberghien (1985); and Garnett, Garnett & Hackling (1995). For example in Driver, Squires, Rushworth & Wood-Robinson (1994) a large number of references concerning students' understanding over a range of topics is included (pp. 176-208). Such topics and references include (amongst others): Nutrition (Barker & Carr, 1989; and Simpson & Arnold, 1982), Reproduction & Inheritance (Bernstein & Cowen, 1975; and Brumby 1984), Ecosystems (Piaget, 1929; and Webb & Boltt, 1990), Materials (Laverty & Mcgarvey, 1991; and Ben-Zvi, Eylon, & Silberstein, 1988), Chemical Change (De Vos & Verdonk, 1987; and Kruger & Summers, 1989), Electricity (Arnold & Millar, 1988; and Solomon, Black, Oldham & Stuart, 1985), and Heating (Tiberghien, 1983; and Engel Clough & Driver, 1985). Whilst many of these references are not recent, more recent references may be found by looking in current Journals.

2.2.1 *Gravity is not understood*

There are a number of studies in this area (Nussbaum, 1985; Baxter, 1989; Mali & Howe, 1979; Sneider et al., 1983; and Stead and Osborne, 1980). Many are based upon the special case of the gravity of the earth. In this case, a number of ideas are present when dealing with these frames of reference in schools. Of particular interest are the following ideas:

- The earth is surrounded by air, which keeps things from escaping. Confusion is occurring between pressure and gravity.

- Spinning can create gravity. Confusion is occurring between gravity and other types of forces.

- Gravity is linked to magnetism. The effects of gravity are being compared with the effects of a magnet on another magnetic material.

With these examples, the unseen force of gravity is related to objects that can be better seen. No attempt is made to define what gravity actually is.

Further to these ideas there exist a number of ideas associated with the earth itself, or the way that gravity works on this planet. Thus, the following ideas exist about what is 'down'. For students there appears to be development from a flat world to a spherical world. Thus, 'down' develops from a surface phenomenon to one of the centre of the earth (Nussbaum, 1985; and Baxter, 1989). Within Driver et al (1994), this development is represented as a series of pictures (pp. 3). The first picture is of the sky and the ground with arrows

leading from the sky to the ground. The final picture is of a round circular planet with down arrows leading to the centre of the planet.

Students are not gaining a basic understanding of science. Here the ideas do not approach close to understanding that gravity is an attractive force between two masses (Nussbaum, 1985; and Baxter, 1989). Further the students in not understanding this specific idea about masses on planet earth are missing out on the power of the theory of gravity in dealing with more general cases, e.g. two masses whose magnitude is relatively close.

2.2.2 Forces are not understood

Gravity is of course a force and as such, there are a number of studies on the more general topic of forces (Osborne, 1980; Osborne, 1985; Watts, 1983; Osborne et al., 1981; Gunstone and Watts, 1985; and Watts and Gilbert, 1985). They suggest a number of ideas associated with force. Initially there are a number of meanings for the word force.

- It is associated with coercion or opposing resistance (As in, the teacher forced me to learn my times tables).

- It is a personal quality associated with animals (As in, the cat looked so cute that I was forced to stroke him).

Within a closer frame of reference to that of the scientist, there exist a number of other ideas.

- If there is motion then a force is acting.

- If there is no motion acting then there is no force acting.
- There cannot be a force without motion.
- When there is motion then there is a force in the direction of the motion.
- A moving object stops when a force is used up.
- A moving object has a force within it that keeps it moving.
- Motion is proportional to the force acting.
- A constant speed results from a constant force.

Further to this is the idea that a force is, is generally only be attributed to a single object rather than many objects. Further, the force appears mistakenly to be connected always with motion. Forces on static objects are not taken into consideration (Sjoberg and Lie, 1981; and Simon, Black and Brown, 1996). There are also a number of research projects that explore the persistence of these ideas (e.g. Finegold and Gorskey, 1991). Sjoberg and Lie (1981) undertook research into the understanding of 1000 upper secondary school students' understanding of forces and describes 50% of them as being unable to accept forces acting on a static body. In more recent research Simon, Black and Brown (1996) investigate a number of students' (aged 6 to 12) understandings concerning forces acting on a static body. They used two examples of equilibrium that of a weight on a rubber band and a heavy object

balanced on a thick piece of card between two bricks. These examples were used to interview students about their understanding of forces on a static object. They conclude that students do have problems understanding the forces acting in this situation. Further, these problems are not currently being addressed within the UK educational system (National Curriculum).

In summary the understanding of forces by students is different from that accepted by scientists (Osborne, 1980; Osborne, 1985; Watts, 1983; Osborne et al., 1981; Gunstone and Watts, 1985; Watts and Gilbert, 1985; Sjoberg and Lie, 1981; and Simon, Black and Brown, 1996). For example, it is not understood that forces can act not only when an object is moving but also when it is static (Sjoberg and Lie, 1981; and Simon, Black and Brown, 1996). Thus from a science teachers point of view forces are not understood by students.

2.2.3 Particle theory is not understood

The understanding of particle theory by students is interesting, as the theory is a basic requisite to understanding so many physical phenomena (Driver et al., 1994). For example, it is used to explain how changes from a solid to a liquid and then to a gas occur. Other uses include an explanation of diffusion, and rates of reactions and the properties of solids, liquids and gases. Thus, it is something that should be of great help to students. It should be emphasised that this basic model of particles does not include the ideas of atoms, compounds or ions.

When probing students understanding of particle theory a number of ideas become present.

- Solids are continuous stuff .The student simply fails to recognise that particle theory is applicable to solids (Holding, 1987).

- Solids are continuous bits of stuff. The student recognises that solids are made up of bits but fails to describe these bits as particles (Pfundt, 1981; Holding, 1987; and Ben-Zvi et al., 1986).

- Liquids are continuous and static. The student simply fails to recognise that particle theory is applicable to liquids and that liquids can flow (Novick and Nussbaum, 1981).

- Liquids contain particles that are widely spaced. Student sees liquid particle model as being halfway between that of a solid and a gas (Dow et al, 1978).

- Gases are not substances. Student fails to see a gas as something that may have comparable properties to that of a liquid or a solid (Johnson, 1998).

The results from investigating students' understanding of particle theory show that many students do not understand that solids or liquids are described in terms of particles. Further, they have problems coming to terms with the existence of gases. Driver et al. (1994) reporting of Holding's work (Holding,

1987) is interesting in that Holding investigated 600 students whose age ranged from 8 to 17. A progression was seen in particle theory (when applied to solids) of: continuous, continuous bits and then finally taught representations. At the age of 17, 20% were still said to have continuous descriptions of solids. Further, the use of the words 'taught representations' might indicate that through they draw the particle pictures they may not understand them.

Recent work by Johnson adds to the above ideas. A slightly different approach is taken to that outlined above. In the above students' attempts to explain solids, liquids and gases are noted in terms of the particle theory. Johnson's approach is to focus upon the particles and the students' use of particles to describe a substance (a solid, liquid and a gas). Johnson uses a series of 'clinical' interviews upon a cohort of students in a secondary comprehensive school. The students are aged 11-14 and the series of interviews lasted three consecutive years.

The results from these interviews suggest to Johnson that students hold four major models for basic particle theory. In simplified terms they are as follows:

- Particles do not exist as an idea to illustrate a substance. The substance is continuous.

- Particles exist in the continuous substance. Thus, the substance surrounds the particles.

- Particles are the substance, but take on the same properties as the substance itself. Thus, they are smaller 'bits' of the substance.

- Finally, the particles are seen to have properties of their own, which collectively describe that of the substance.

Whilst Johnson suggests why students are not progressing towards an adequate particle model that enables them to explain what a substance is, the fact still remains that most students do not progress and have little understanding (if any) of basic particle theory.

2.2.4 The process of combustion is not understood

The understanding of combustion by students has been extensively researched. The number of references given below shows this. For example, Andersson (1990) gives a number of references in this field. These references include: Andersson & Renström (1981, 1983a, and 1983b); Pfundt (1982); Shollum (1982); Andersson (1984, and 1986); Mehuet, Saltiel & Tiberghien (1985); and de Vos & Verdonk (1985a, b, 1986, and 1987a, b). Through a careful consideration of the materials, five major categories of models for combustion are obtained. When looking at these categories of responses, there is a need first to consider examples of questions that are being asked to the student.

One major question that has been asked concerns petrol in a car. In simple terms, a car is filled with petrol and driven until the petrol tank is empty. What has happened to the petrol?

A second question commonly involves a lit candle. Typical questions are: 'what is happening at the flame?' and 'What is happening to the wax?'

- Disappearance- the substance being burned simply disappears. Andersson gives the example of petrol in a car. The car uses up the petrol. The petrol disappears. Little if any of it turns into the exhaust.

- Displacement- the resulting substances after the combustion were originally held in the substance being burned. Thus, for example when a wax candle burns and a cold beaker is held over the top of it, the resulting water was first locked up in the wax and has now been released.

- Modification- The new substance is seen as being the same substance but in a different form. Thus with a candle the liquid being formed on the cold beaker is liquid wax. Thus the wax has changed from a solid into a liquid.

- Transmutation- one chemical substance 'magically' changes into something else. Thus in the car burn petrol case, some of the petrol turns into heat. A second change is from energy into a chemical substance. Thus, the heat from a candle changes into the water formed when placing a cold beaker above it. Finally, a third change is

that of one chemical substance changing into another. Thus, the wax from the candle changes into the water formed on the cold beaker.

- Chemical interaction- this is the acceptable explanation of how the chemical reaction occurs. Thus for the petrol problem the petrol combines with the oxygen to form amongst other products water and carbon dioxide. Thus, the exhaust gases weigh more than the petrol.

The categories of students are interesting in themselves. The interest for this study lies in the fact that very few students are actually able to give a satisfactory answer to problems such as the car problem or the candle problem (Andersson, 1990). Andersson reports only 2% of students being able to give an answer that fitted into the category of 'chemical interaction' to this problem (Andersson & Reström, 1981, and 1983 a, b). Further, this was after being given instruction. With the candle, only one out of 150 students were able to give an answer that was placed into the same, chemical interaction category (Watson, Prieto and Dillon, 1997). Thus, in short, for the examples given combustion is not understood by students.

2.2.5 Skeletons are not understood

So far, the concepts mentioned have been from what may be described within schools as being physics and chemistry. Students' understanding in other biological areas is just as poor. A recent study undertaken by Tunnicliffe and Reiss (Tunnicliffe & Reiss, 1999a) looks at students understanding of animal skeletons. There have not been large amounts of research in this area

(Tunnicliffe & Reiss, 1999a; and Driver et al., 1994). Examples exist for mostly human skeletons and include: Gellert (1962); Williams et al. (1989); Osbourne et al. (1992); Guichard (1995); and Cox (1997).

In Guichard's research (Guichard, 1995) only three percent (92 students were used in total) were able to draw a basic outline of the human skeleton. Guichard performed another test on the same students six months after the initial test and after the students had received some further basic tuition on human skeletons. After the second test only eighteen percent (92 students were used in total) of the students were able to draw basic human skeletons. Further additional confusions in terminology and the nature of the rib cage occurred (i.e. rib cages were drawn as 'fish bones'). Further, no student was able to attach muscles to the bones in a manner to indicate some understanding of the working of muscles in skeletons. Even when trainee teachers and primary school teachers were asked to draw 'a functional diagram of the arm to show how it is used in movement' only 12% of trainee teachers (total of 115) and 28% of primary school teachers (total of 78) were able to draw a diagram approaching that to be considered correct. From this Guichard concludes that students have little if any understanding of human skeletons and further traditional school does little to change this.

Tinnucliffe & Reiss take a different approach to looking at students understanding to those mentioned in previous sections (2.2.1, 2.2.2, 2.2.3), which is similar to Guichard's outlined above. Rather than interviewing students using a clinical interview approach or using drawing and interviews,

they showed students stuffed animals (a rat, starling, herring and crab). With each stuffed animal the students were requested to draw what they thought was inside the animal when it was alive. One advantage that this held over interviewing students is that there are no language barriers to overcome. These drawings were requested from a number of students during various stages of their education. For example, some students were primary school students. Others were secondary school students and finally some were taking a Bachelor of Education course. The results were analysed by the two researchers individually and then comparisons made between each individual's analyses. For the majority of the pictures the scoring was similar.

From the analyses, an illustrated level guide is provided. A brief summary of these levels is provided below.

I. No bones

II. Bones as simple lines, and elliptical shapes.

III. Bones of 'dog bone' shape and randomly distributed within body shape.

IV. One bone correct shape and in correct position.

V. At least two bones correct shape and correct position.

VI. Bones organised in a definite vertebrate skeleton (though not necessarily the correct organisation).

VII. Bones organised to show a comprehensive skeleton.

There are differences here between those obtained by Guichard. Guichards levels are given below. In addition to the word descriptions given Guichard also provides illustrations.

i. Bag of bones

ii. Fish-Knuckle-bones

iii. Stick members

iv. Chain of Knuckle bones

v. Correct diagram

For example, Guichard only uses five levels as opposed to seven. Further Guichard's system highlights confusions (drawing rib cage as a fishbone) whilst the levels Tunnicliffe & Reiss use illustrate a positive progression (i.e. level 2 shows more correct features than level). It does not try to measure additional features that may be incorrect.

What is disturbing with the research of Tunnicliffe & Reiss is that whilst the students' drawings of human skeletons showed little understanding of the skeleton, those of the other animals showed less understanding (Tunnicliffe & Reiss, pp. 1198). This lack of understanding was particularly prominent in the drawing of the starling (Tunnicliffe & Reiss, pp. 1198). Slightly higher levels of understanding were seen for those skeletons of the rat, and fish (Tunnicliffe & Reiss, 1999a). Suggestions as to a possible reason for this are that this is due to experiences of these skeletons outside school settings and not due to teachings in this area (Tunnicliffe & Reiss, pp. 1198). Further

problems with understanding the skeleton were still seen in those drawings made by undergraduates. Tunnicliffe & Reiss conclude that:

> *Our belief is that too few of the students, whatever their age, had any genuine understanding of skeletons, even their own. There are a range of teaching approaches which would facilitate such a holistic overview (Tunnicliffe & Reiss, pp. 1199).*

With regard to the data collected and the subject matter of the topic. Tunnicliffe & Reiss expressed an interest in exploring further students' ideas and understandings using interviews and animals as a basis. They found that when asking students to draw they had problems understanding what the students had drawn and interviews with the students after having drawn the pictures may have been useful. Further to them, a logical progression from looking at pictures of animals' skeletons was that of talking about the animals.

2.2.6 Animals are not understood

Students' understanding of animals is an area that has been extensively explored. This statement is supported by the many references (totally 36) available within Driver, Squires, Rushworth & Wood-Robinson (1994). With regard to the classification of animals a consistent finding is that students classify animals not in accord to a biological classification, but rather according to personal intuitive reasoning. Thus, Trowbridge and Mintzes (1985) report jellyfish and starfish being classified as fishes and turtles being classified as amphibians. These findings are similar to those found by Ryman (1974) and Braund (1991) (Driver, Squires, Rushworth & Wood-Robinson,

1994). More recent studies include those of Tunnicliffe & Reiss (1999b), Strommen (1995) and Brody (1994).

Tunnicliffe & Reiss (1999b) interviewed students from two state schools. The students' ages ranged from five through to fourteen years of age. The students were presented with six stuffed animals. They were asked: to name and put the animals into groups, and to explain how they had done these things. The main way that students grouped the animals was through the actual physical features (anatomical) of the animals, rather than with regard to the places the animals lived (habitat). Part of the table presented by Tunnicliffe & Reiss (1999b) is given below.

Table 3 Students' animal groupings

Reason for grouping	5years	8years	10 years	14 years	total
Anatomical	4	4	6	4	18
Habitat	0	0	3	2	5
Other	6	9	9	9	33

Whilst it is possible to say that students chose to group the animals in this manner as the anatomical features were placed in front of them and their

habitats were not, Tunnicliffe & Reiss suggest that there may be other reasons for the students grouping them in this manner. One thought is that this is due to teachers over emphasising naming animal parts rather than developing students ideas about where the animals live. Tunnicliffe & Reiss concur with Brody (1994) and Strommen (1995) in suggesting that 'few students have an integrated understanding of environments' (Tunnicliffe & Reiss, pp. 146).

Work by Strommen (Strommen, 1995) focuses more upon the habitat of a forest and what animals live in a forest. The twenty secondary school students (first year) were asked to draw a forest with as many things as you can in it. The students were then interviewed a few days later. In the interview the students were asked about the drawings, what a forest is? And what things are in a forest? Stommen discusses from the results of these pictures and interviews three findings with regard to the students' knowledge.

- Students overestimate the number of large carnivores in forests.
- Students do not distinguish between sea and fresh water environments.
- Students placed animals not normally associated with forest environments into forests (e.g. Lions, and elephants).

In conclusion, Stommen suggests that students' ideas are 'imprecise' and very 'global'.

Brody (1994) rather than using a forest environment uses an ecological crisis. A real life example of the gulf of Maine between Canada and USA where acid deposition and pollution is occurring is used. Researchers develop a complex concept map (see Brody, pp. 425). Work by Novak and others give a full description of a concept map and its uses in science education (see Novak and Gowin, 1984; and Novak, 1990). In simplistic terms, a concept map is a diagram containing key ideas and their relationships for a specific (scientific) topic. From his map focus-questions are developed to ask in interviews. Some 467 students from lower middle and upper secondary school ages are interviewed.

After the analysis of the interviews, Brody concludes that:

> *It seems that many students do not understand or appreciate the significant role of the environment.....*

The basis of this statement is that students in lower school years appear to have very basic views of the environment. Further, in higher year groups little difference was found between those in the lower years. In other words, it is likely that as students progress through school their understanding of the environment remains low and they do not learn much more about it.

2.3 Summary

During this section evidence has been presented to support the idea the students dislike science and that science is not understood by them.

The majority of students do not like science and hold negative attitudes about it. These attitudes create peer pressures and expectations, which in turn create more students with poor attitudes. Thus, a vicious circle needs to be broken in order to overcome the problem.

Evidence has been presented to support the idea that many topics of science are not understood by students. This has been achieved by giving a number of examples where previous research has probed students' understanding. This probing has pointed conclusively towards students' having little or no understanding of the topics explored. Further examples are available to illustrate students' lack of understanding. References have been presented, so that should further evidence be required it is at hand.

What is now required is a consideration of the possible relationship between these two areas. The main line presented within the literature is that a way of breaking the vicious circle of dislike for science is to change the context of the learning to a more appropriate one (Solomon and Aikenhead, 1994). Not only will this effect students' dislike of science, it will allow them to understand science (White & Gunstone, 1992). Thus, what we have is a relationship between students disliking science and not understanding it (in one direction, from students disliking science to them not understanding it). This is supported within the literature reviewed (Solomon and Aikenhead, 1994; and White & Gunstone, 1992).

However, the reverse relationship that students don't understand science and so do not like it is not supported. This area requires further attention. Thus, the intention of this research is to assess a sample of students to find out if they dislike and lack understanding of science. After this and at this point it was decided to then apply an intervention based not upon changing the context of the science, but rather by tackling the lack of understanding by carefully considering what students should learn to understand it. This process involved trying to produce a science curriculum that would allow, when presented appropriately, students to understand science (Johnson, 1995). Finally, the students will be reassessed to find out if the situation has improved or not. There are three possible results. They are that; the intervention will improve their understanding and the students still disliked science, that the intervention will improve the students' understanding and the students now like science, and finally the intervention will not change students' lack of understanding or dislike of science.

Chapter 3

METHODOLOGY OF THE RESEARCH

The assessment of the sample

3 Introduction to the methodology

The intention of this chapter is to describe and justify the methodology used in this research to assess the sample's dislike and understanding of their experiences of secondary school science. The description of the procedure followed will occur in terms of: the type of sample, the methods and the design used. This description will then be justified by a detailed comparison with a similar piece of research.

3.1 The Sample

To initially assess the sample a brief educational background was obtained from those students to be the main focus of the research. This background was to be obtained by requesting that the students complete a 'Questionnaire on school History'. The aim was to assess quickly, the type of students that were present. Initially it was known that these students were Bachelor of Education (B.ED.) students and that they numbered 74. Further, the majority of these students were female and had recently left secondary school education. Previous research into B.Ed. students (e.g. Coates & Russell, 1995) also suggested that it was likely that these students had studied non-scientific 'A' levels, disliked science and did not understand it.

Whilst, it is possible to argue that the main property of this sample is convenience, it is difficult to see how a more applicable sample was to be found. The students in the sample were articulate in that they were mature and so able to express themselves. They had recently left secondary school, so their experiences of secondary school science were fresh in their minds. They probably did not like or understand science. Further, they were not in a situation where their former secondary school peers or teachers might influence their expression of their feelings. Thus, all that would be required would be to allow these students to express these feelings in an appropriate manner.

3.2 Methods used

So starting with this basic knowledge of nature of the sample, the intention was to delve into their perceptions of science and understanding of it. The students were considered initially at the beginning of the second term of their University course. The consideration was of their past experiences of secondary school science not the science that they had just begun to learn.

The University Science course was an intervention, which aimed to expose the students to an improved science curriculum that would aid them in their understanding of science. The intervention was not aimed intentionally at making science more likable. After analysing the initial consideration, it was decided to reconsider the sample by reflecting their current science experiences upon those of their past (secondary school science). Thus, a new set of questions were developed and asked to the students. With both

considerations trials were first undertaken, followed by refinements and then a full application.

During the first consideration, I the assessor was introduced to the students. I requested to speak to the students about their past experiences of secondary school science, emphasising that this was confidential research and was not part of their University course. A number of volunteers came forward.

At the beginning of the initial consideration, the students were asked to complete a questionnaire on their school history. The questionnaire asked questions about the schools they attended and the type of examinations that they took. Following this a structured formal interview took place in which a number of information gathering questions were asked about the students past experiences. Due to the use of the interview as the main method used to gather information, additional questions were enabled, as was the possibility of expansions upon questions. These additional and expansion questions allowed students to give full and well thought out answers.

The initial consideration was then followed by a re-consideration of the sample in the form of a shorter but more structured interview. The re-consideration was supplemented by other additional information where available and relevant. It must be emphasised here, that this re-consideration was not originally planned. However, it seemed too good an opportunity to miss. The students had experienced what was thought to be an improved science (Gott and Johnson). It would therefore be an opportunity to try to

consider if the students' perceptions of science had changed as a result of this experience.

3.3 The questionnaires used and the questions asked in the interviews

The questionnaire used to establish the background of the students is given below.

Table 4 Questionnaire used in main assessment

Questionnaire on school History

NAME_____ COLLEGE _____

COURSE _____ SEX M/F _____

NAME OF SECONDARY SCHOOL ATTENDED: _____

LOCATION :TOWN AND COUNTY _____

TYPE OF SCHOOL ATTENDED DURING SECONDARY EDUCATION (PLEASE TICK)

COMPREHENSIVE ☐ PRIVATE ☐ 'GRAMMAR' ☐

CO-EDUCATIONAL ☐ SINGLE SEX ☐ OTHER.....

GCSEs and A levels studied whilst at secondary school (please mark GCSEs in the left column with the appropriate grade and A levels with an appropriate grade in the right column)

ART		FRENCH	
BIOLOGY		GERMAN	
CHEMISTRY		HISTORY	
CRAFT, DESIGN AND TECHNOLOGY		MATHEMATICS	
DRAMA		MUSIC	
ENGLISH LANGUAGE		PHYSICAL EDUCATION	
ENGLISH LITERATURE		PHYSICS	
GEOGRAPHY		RELIGIOUS EDUCATION	
FOOD SCIENCE		SCIENCE (GENERAL)	
		OTHER	

What years did you attend secondary school: _____

ALL DATA PROVIDED IS FOR RESEARCH USE ONLY AND WILL BE TREATED AS CONFIDENTIAL

The subjects mentioned cover a broad range and it is hoped that the majority of the students will be able to simply fill in the appropriate boxes rather than

having to write in the subjects that they studied. Further, the final question (What years did you attend secondary school?) also gives the age of the students. A questionnaire was used to get this information, as it seemed a quick and efficient method. For example, to collect this information using an interview method would become repetitive and would likely take much longer.

Following the questionnaire, the students were individually interviewed. The interview schedule used is included along with the additional materials in the appendices (see section 7.1). These materials include typical secondary school science equipment (e.g. Bunsen burner), worksheets and teaching materials. The interview was tri-partite; the first section explored their experiences of secondary school with regard to school subjects; the second focused upon secondary school science, and finally the last acted as a summary. Whilst the questions featured in the schedule were asked to all interviewees, additional questions not listed in the schedule were asked as and when required.

The questions asked during this the first consideration of the B.Ed. students may be summarised in terms of the following six questions:

Table 5 Key questions used in main assessment

1. What subjects did you study at school and what grades did you achieve? 2. Did you have any difficulties choosing? 3. What sort of pressures were you under when taking these examinations? 4. How did you learn science at school? 5. What do you think would be occurring in the classroom given this equipment? 6. Given these worksheets, what would be occurring in the classroom?

The first question was covered in the questionnaire and the remaining questions were covered in the interview. The questions related closely to the sections covered in the literature review; Questions 2 and 3 are the students' attitudes, question 4 is their understanding, and finally question questions 5 and 6 give the interviewee the opportunity to support their statements using examples from secondary school science lessons.

The students were interviewed again following their first year. These questions will not be presented to the reader at this point, as they were developed from the answers given by the students to the first interview and thus form part of the results to the first interview. They will be presented to the reader in the results chapter (chapter 4).

3.4 The application of these instruments

In applying these instruments (questionnaire and interview) to the sample, a number of steps were taken to ensure that any data collected was usable as evidence to make comments about these B.Ed. students' past liking (did they, or didn't they like it), and understanding of science (did they or didn't they understand it). Initially I was introduced to the students. I asked for

volunteers to interview about their past experiences of secondary school science education, saying that I had a set of questions to ask them. From this convenient times were arranged to interview the volunteer students. To ensure that the data collected was valid and reliable and number of steps occurred.

3.4.1 Step one

One of these steps was a validation of the data through the careful consideration of the questions, words and manner used to apply the instruments. The intention was to enable: the students to understand the questions being asked; the collection of much relevant data as possible; and the students to feel uninhibited.

The questions and words used were considered through the use of trials and to a certain extent from a development of the instruments throughout the assessments. If students were asked a question and did not answer it, then a possible explanation is that either they do not understand it or do not have an answer to it. In the former case then attempts were made to make the language used as simple and free from 'jargon' as possible. In the latter case, if the question was considered to be relevant to the research it was still included.

The manner was considered to collect as much relevant data as possible. To do this, students were often asked encouragement questions. It ought to be mentioned that these questions were aimed at encouraging the students to

answer rather than trying 'to put words into their mouths'. So these questions were kept short so that few new words were used and detraction from the original question did not occur.

It was hoped that the students would be uninhibited in their response. In being free to talk the intention was to get at what they really felt about their past experiences of secondary school science. The students' inhibitions were lessened, by applying the instruments in surroundings with which these students were familiar. The atmosphere that was encouraged within the assessments was one of a 'formal chat'. It was formal in that the interviews were being recorded (with the students' consent) and it was hoped that the students would actively try to give truthful answers to the questions asked. Additionally there was a problem here that needed to be solved and with which they might be able to help. It was a chat in that students were told that it did not relate to their courses and their answers were not being considered to be right or wrong. Thus, the intention was that individuals expressed their personal opinions rather than those of others.

3.4.2 Step two

A second step was a validation of the data through a careful consideration of the type of the sample used. The main point being that the members of the sample are not presently at secondary school. Thus, the intention is to deal with past events rather than present events.

A problem that would arise if the instruments were applied to secondary school students (i.e. present events) would be that they would feel inhibited by pressures and expectations placed upon them by their peers and teachers. They would likely not feel comfortable in talking about these pressures and expectations, which is something that is required. The fact that the materials collected are confidential would not totally qualm these inhibitions. This is as whilst it can be expected that the interviewer will not divulge information to third parties, those interviewed will most likely be questioned afterwards by their peers and teachers. Further the secondary school students would also feel inhibited knowing that they were talking about their peers and teachers 'behind their backs'.

To overcome this problem, one solution is to have group interviews. This then presents the problem of how to measure the expectation and peer pressures actually occurring in the interviews. Further problems arise in that recording what is being said in the interviews becomes much more complex. Thus, a good solution to these problems appears to be to talk about past events on an individual basis. The students would not then be talking 'behind peoples backs' and would not fear being 'cross-examined' by those peers and teachers concerned after the interviews.

3.4.3 Step three

One further step for the validation of the data is the ability to 'probe' students' answers. Thus, once a student has given an answer to a question and interviewer will use further questions to ascertain exactly what the student

means. Without this ability, students say things that they do not mean and make ambiguous statements. By using probing questions these and meaningless statements are reduced. Such probing questions might be 'So what do you mean by...' or 'can you explain that further?'

There is a certain amount of skill needed on the interviewer's part in order to spot possible ambigualities and meaningless statements. The interviewer has to think quickly and be prepared appropriately. Further, the interviewer must realise that in probing the student's answers, the student is being put under some stress. Thus, it is a balancing act. The answers given by students need to have meaning and relevance, but the student needs to feel relaxed (not overly stressed). To help me make these judgements within interviews, I saw the trial interviews not only as an opportunity to develop the questions asked, but also for me to gain the knowledge of how to 'probe' student's answers. Further, I read various guides on how to interview students (e.g. Brenner, Brown & Canter, 1985; Foddy, 1993; Hitchcock & Hughes, 1995; Maykut & Morehouse, 1994; Oppenheim, 1992; and Osbourne & Freyburg, 1985).

3.4.4 Step four

When collecting data there is uncertainty in that the quality and amount of data to be collected is not known until after the collection has taken place. Thus opportunities and thoughts as how to get alternative and additional data have to be considered. For this research, it was decided to collect additional data to explore further changes in students' perceptions of science. This additional data collection was only a possibility due to this awareness.

Further, it also has to be considered that it is always useful to collect data in a number of different ways. For example in this research, data is collected in a literature review, through a questionnaire and through structured interviews. The use of additional ways may give insights into areas not covered by the original sources. Thus, a much fuller picture will be obtained. However, there is a need to consider if these different methods are going to fit together and supplement each other. One way of doing this is to consider the ways used in other similar research literature and then compare them to those used here. If similarities are found then the use of these methods here is justified.

3.5 A Comparison of these methods to those used in similar research

None of what has been said in the former section is particularly new and many examples are available to confirm that interviews and questionnaires have been applied in other studies, (see Driver, Squires, Rushworth, & Wood-Robinson, 1994; Osborne & Freyberg, 1985; and White & Gunstone, 1992 for examples). The aim now is to justify the use of these methods in this situation by referencing them with similar studies. Essentially, the intention of this research, as described in methodological literature, is probing students' perceptions in science.

3.5.1 Students' Perceptions

In the research of students' perceptions in science, much work has developed through the Piagetian clinical interview approach of the 1920s (see Piaget, 1929). These interviews in a modified approach are commonly used to consider students understanding of specific scientific concepts such as

combustion, gravity and electricity. With these interviews, two types of questions are described. They are questions concerning instances and those concerning events (Osborne, & Freyburg, 1985). The instance questions focus upon specific words and what the students mean when they use them. So for example students might be asked about what they mean by the word 'burning', 'current' or 'gravity'. The events deal with science situations that may actually be occurring in the interview or have occurred in the student's past experiences. These events are normally described using interview props such as drawings and pieces of equipment. An example of this might be a candle placed in a jar or a picture of an apple falling onto a person's head. The former may be a context for combustion and the latter for gravity. As well as dealing with science concepts, literature on this topic is present saying that interviews may be applied to past situations that do not necessarily involve science concepts (Osborne & Freyberg, 1985). It should therefore be possible to find examples of similar research in this area (see section 3.6).

3.5.2 what is 'probing'?

Probing means that we are trying to explore what the students are saying. In this case and many others, this exploration involves the construction of meaning. Usually in major studies, this construction involves the students' understanding of a concept. This research does not go this far and is more specific. Here the intention is to bring a construct in meaning to students' perceptions of a past situation (a concept). The students' perceptions are described by most literature (White & Gunstone, 1992), as being part of their

understanding and past situations may be the learning of such concepts as combustion or gravity in school. Thus, the approaches used in this research can be considered as being similar to those used in other larger scale studies. So when considering the types of sample, design and methods used, in this research, similarities should be seen between those of this research and the larger scale studies. Therefore, these types (of methods, sample and design) in larger scale studies could be used to compare with those used in this.

3.6 A Comparison between the research methods presented above that those reported in Orion & Thompson (1999)

Orion and Thompson's paper is entitled 'Changes in perceptions and attitudes of pre-service Postgraduate Secondary Science teachers: A comparative study of Programmes in Israel, England and Wales'. In the abstract of the paper the following two sentences give some insight into the nature of the paper.

> *'This study dealt with the development of English-Welsh and Israeli pre-service secondary science teachers immediately before and after their initial teaching education (ITE) courses. Data were collected through a questionnaire and interviews conducted during and at the end of courses' (Orion & Thompson, pp. 165)*

There are some similarities and differences here between Orion & Thompson's' study and the research undertaken here.

3.6.1 Similarities

The main similarities are: the samples for both are pre-service teachers who are being taught how to teacher science to school students; and in both data

are being collected to find out about their perceptions of secondary school science.

The first similarity suggests that to collect data from pre-service is a viable option. In Orion & Thompson (1999) and other references (Gustafson & Rowell, 1995; and Orion & Thompson, 1996) conclusions are drawn based almost solely upon this data (some literature references are also included). Further, in these cases the data collected was able to uncover some of the students' perceptions of school science. So there should a real opportunity to obtain the perceptions of the B.Ed. students interviewed in this research.

3.6.2 Differences

Two differences are that: In this research the pre-service students are going to teach primary school students, whilst Orion and Thompson's are going to teach secondary; and secondly that in this research volunteers were used whereas Orion & Thompson (1999) chose students based upon the advice of lecturers.

Because the students in Orion and Thompson's paper were trainee secondary school science teachers, many of the questions asked in the questionnaires and interviews evolved around the actual course they were taking rather than past experiences. This did cause some problems in that students felt apologetic when being critical of secondary school science. This is seen in the following quotation:

'.....I apologize for being so outspoken and straightforward, maybe even rude' page 187

This particular student clearly felt restricted in what could be said during the interview. This restriction was also found in Gustafson & Rowell (1995), which was reported within Orion & Thompson (1999). Here Elementary school science students were used and they were interviewed about a number of topics including the role of science in the elementary curriculum and the nature of science. Within these interviews Gustafson & Rowell suspect that the students may be...

'..reluctant to espouse them [beliefs] publicly.'

Hopefully in talking about past events rather than present ones students will feel more open and less reluctant about talking about their beliefs.

On the other hand there are possible difficulties as well that will arise from discussing past events rather than present ones. For example, students are likely not to remember as much about past events as present ones. Driver et al. (1998) and King (1990) suggest that students do have some strong recollections of certain school experiences and of these, perception of science is said to be one.

With regard to the difference of sampling methods, there is a problem of how representative those assessed are of the whole sample. Perhaps a true representation would have to be very random. However, if those assessed

were chosen totally randomly perhaps some of those chosen would not want to talk to an interviewer about their science perceptions.

Orion & Thompson (1999) take the advice of the students' lecturers as to who are representative of the whole sample. So one question that might be asked here is; how do the lecturers know who are representative of the whole sample? I guess that to some extent the question of how representative those assessed are of the whole sample is a matter of judgement. Those assessed in my sample were all volunteers and as such all wanted to talk to me about their experiences of secondary school science. This causes me very few ethical difficulties. However, they may not be truly representative of the whole sample.

Chapter 4

THE RESULTS

The Students' perceptions of secondary school science

4 Introduction to the results

The aim during this section is to explore the students' and their perceptions of secondary school science. The students will first be described in terms of the results obtained from the educational history questionnaire. This will give an indication of the variation of the type of student present and the subjects that these students studied at secondary school.

Their perceptions will be explored in terms of whether they felt able to do science (i.e. did they not understand science or understand it.) and whether they wanted to do it (i.e. did they dislike it or like it). This should add to or subtract from the literary evidence shown that suggests students dislike and don't understand science.

As a result of these findings it was decided to develop a second interview that would assess the students' perceptions after the first year, B.Ed. science course. So the questions asked in this interview will be presented to the reader. This involves the students placing themselves categories of dislike/ like science and don't understand / understand it. Further, they are given the opportunity to express these feelings with regard to two areas of science

(combustion and gravity) that have been studied in this course. Thus to some extent possible changes due to the intervention are assessed.

4.1 Exploration of the students

The intention here is to present the data collected from the school history questionnaire. During this section, general information is obtained about the schools attended by the students, and the sex and the dates of attendance of the students. Each member of the sample interviewed is given a code for ethical reasons.

Table 6 Type of sample

code	location	type of school	sex	years attended
bb	Accrington, Lancashire	c,co	f	88-93
xx	Shildon, Co. Durham	c,co	f	88-93
aa	Milton Keynes, Bucks	c,co	f	90-96
hh	Ilford, Essex	c,co	f	89-96
oo	Newtownords, Co. Down	g,co	f	89-96
gg	Sunderland, Tyne & Wear	c,co	f	89-94
tt	Norton, Cleveland	c,co	m	83-88
ll	Lincoln, Lincs	c,co	f	89-96
uu	Calne, Wiltshire	p,ss	f	90-95
cc	Barnard Castle, Co. Durham	p,ss	m	90-94
kk	Gateshead, Tyne & Wear	c,co	f	89-96
mm	Middleton, Rochdale, Manchester	c,co	f	89-96
ww	Edinburgh, Scotland	p,ss	f	89-95
jj	Ardingly, West Sussex	p,co	m	90-95
pp	Berkhamsted, Herts	p,ss	f	89-96
ff	Scunthorpe, N. Lincs	c,co	f	89-94
rr	Billimgham	c,co	f	89-94
dd	Branston, Lincs	c,co	f	89-96
vv	Solihull, West Midlands	c,co	f	86-91
ee	Washington, Tyne & Wear	c,co	f	87-92
ss	Banbury, Oxfordshire	c,co	f	87-96

m=male, f=female

p= private, g= grammar, c= comprehensive, co= co-educational, ss= single sex

With respect to where the students studied, a broad area covering many of the areas of the UK is present. There are students from Scotland, Northern and Southern England, and Ireland present. There is a slight bias towards Northern England. The majority of students attended comprehensive co-educational schools. There are in addition students who attended private, grammar and single sex schools. Twenty of the twenty-three students were female. The majority of those interviewed had recently left secondary school or Sixth-form College.

In addition, there is information about the subjects that these students studied and the grades that they obtained in these subjects.

Table 7 Subjects studied by students at A-level

	A-Levels English Subject	*History*	*Geography*	*Modern Lang*	*Science subject*	*Maths*
entries	16	8	8	6	3	2
grade a	4	0	2	0	0	0
grade b	7	3	3	2	1	0
grade c	4	3	1	3	1	2
grade d	1	2	1	0	1	0
grade e	0	0	1	1	0	0
other	0	0	0	0	0	0

The table includes the main subjects of interest to this study. A complete table is included in appendices (section 7.2). From the table it is noticeable that not many students chose to study science. Further, when a comparison between science and English is made, the science grades appear to be lower than those in English.

4.2 The B.Ed. students' perceptions of secondary school science

In this section, the B.Ed students' perceptions of secondary school science will be illustrated and interpreted. This will be achieved using selected quotations from the transcriptions of the recorded interviews. These quotations are explained in terms of the context of the interview and the information already presented within the literature review. Thus, there form a number of categories into which the quotations are placed. These categories are 'I dislike science', 'science is not understandable', 'I like science', and 'science is understandable'.

4.2.1 'I dislike science'

The first category to describe is that of dislike of science. The intention is to try and illustrate some of their dislike for the subject and to find out exactly what the students mean by 'I dislike science'. Major themes that appeared within this section were that science was disliked because of it having a bad image, and the way it was taught.

4.2.1.1 *Sciences had a bad image*

> *pp: Erm I don't think it really did, at one point when I was thinking about psychology, you can either go in to it arts based or science based ...erm so that may have influenced it. I think it was important for me to do the subjects I enjoyed and that I was generally a bit better at than struggling at something I didn't enjoy doing.*

This quotation is from a student, who had a number of siblings that studied science. In spite of this or perhaps because of this she did not want to study science. Further, the student expresses the idea that all subjects are divided into two areas (science and arts). The sciences are subjects that are not enjoyed.

> *ss: ...I think that maybe ....kids build up an idea of what science is supposed to be like , well particularly with girls I used to have a lot of friends say oh I hate science just probably because of the image in their head that they had of it, which oh no not another science lesson, oh god we have got to do whatever with Tt..... I think that it affected it in that way. It didn't in my case, but I saw a lot of my friends had a bad image of it*

ss in this case points to science having an image. Further, this image was held by a number of her friends. Further, this image is a negative image and it may

be that, in this case, peer pressure is being exerted on students not to study science.

> *vv: definitely didn't want to take science mainly because it has got. I don't know. People seem to presume that it is going to be very hard to do. And there was the idea given that if you weren't very good at it, A s and sort of things at GCSE, then it was probably not a good idea to do it.*

This student chose not to do it because of the image that science was an academic subject. In other words, to continue to study science, there was a need to achieve high grades in science examinations. Further, on in the interview, the interviewee also mentions the male image of science.

> *vv:[T] he media's main view of science is that it is a male subject. I think that that is half the problem. Girls are conditioned to think that it is not the subject for them. It has changed slightly since I was at school.*

This quotation is of note in that the interviewee acknowledges that science does have a male image. However, she does make the point that this is changing and she does not express this image as one that she upholds.

> *kk: we did just science all together. So it was obvious that it was split up into chemistry, biology and physics, but it was just like called science... I don't know. I was never fussed with it really. It didn't appeal to us. It didn't interest us. I didn't enjoy it at all.*

This quotation is of note in that some of the students mentioned a particular like or dislike of certain types of science. This student blankets them together and simply dislikes all the sciences. When pushed further, later on in the interview, this student said that science was boring because they never really did anything in the lessons. They just sat and watched. Thus, the subject really didn't have any impact on the student, so it was irrelevant.

Another student further highlights this irrelevance, by saying:

> *cc: I think that things like GCSEs the A levels should be move with the times. I.e. some of the things that the teachers say are so out of date. I can't think of an example. It is so totally what is the point of learning it. You will never ever use it.*

At this point in the interview, we were talking about what happens outside school and how the science taught relates to this. This student feels that the science learnt in school does not relate to the outside school environment and so it is useless (irrelevant).

The bad image presented by these quotations, is similar to that presented within the literature review, i.e. science is male, academic and irrelevant (sections 2.1.2, 2.1.1, 2.1.3, 2.1.4). Thus, this bad image is part of their dislike for science. It is not the only part. This is seen in the quotation given by vv about science's male image in that she describes it as being an image, but not one that she upholds. Yet still, she dislikes science. Further, the last quotation given was by a one of the few students who did take a science

related 'A' level (Computer science). Another form of the students' dislike was that of the way it was taught.

4.2.1.2 The way science was taught

> *kk: It was more a case of us sitting and watching and I didn't like that it was too it was too boring*

This student dislikes the way that it was taught. The student sat and watched the teacher perform practical demonstrations of science experiments and videos on the topic of science documentaries.

> *rr: science at school it was extremely boring....I was supposed to be going into a science lab for a science lesson, but we may have gone into a normal classroom really and copy what was in a book and I think that that was why I didn't like it so much.*

This quotation suggests that secondary school science was disliked due to the way that it was taught and what they were expected to learn. The science was irrelevant. The expectation was that you copied out the science from books, memorized the facts and simply used them to pass the examinations.

> *aa: I didn't like it . . I think that it might have something to do with the fact that we weren't actually taught it.*

This particular student, states that she did not like science. Further, she goes onto explain that it was the way she was expected to learn the science. This is

what made her dislike science. She describes the way she was expected to learn it in the following quotation.

> *aa: It was a bit bizarre. There were some cards at the front of the classroom which when you finished one you went and got another and if you were lucky about once a term the teacher would stand at the front of the class and tell you something [.]*

This is what the interviewee meant by not being taught the subject (mentioned in the first quotation). The students did not have much contact with the teacher. Further, the teacher did not take an active role in their class. The student did not like this.

> *kk: I hate Bunsen burners... I could never light a Bunsen burner. I'd watch from here, but I'd have to find someone who could ...who I know isn't afraid of things like that... (Response to question 5)*

This student expressed a particular strong negative response merely to seeing a piece of equipment associated with the science lessons. Not only was this hate of the Bunsen burner evident in what she said, but also in her body language. She backed away from the equipment.

The first and second quotations are concurrent with research thoughts on this topic. That is, science is memorized through repetition without trying to learn it (Meece & Jones, 1996). The third and forth quotations are interesting comments about the way science is taught in secondary school. Student

centred learning and practical work in science lessons is said to be an improved way of teaching science. These ways are said to make students like science (Woolnough, 1991), but in this case, the students still dislike it.

As well as students' dislike of science, students also perceived a lack of understanding of it. Thus, these perceptions of lack of understanding of science will now be explored.

4.2.2 'Science is not understandable'

Initially the thought that the students did not like science, due to not understanding it, appeared when they were presented with pieces of science practical equipment. In many, the dislike for the equipment was obvious from their initial response. They often drew back from the equipment and pulled faces indicating this. Further, when they talked about the equipment it became clearer still. They had all used this equipment in their lessons in secondary schools. They did not know any science experiment in which the equipment could be used. Further, many students simply stated that they did not like science in secondary school because they had not understood it.

> *ww: I always found I never understood them at school I was always just presumed. A lot of things we were just presumed to know. I didn't know them and I didn't understand them. I don't understand them if I'm told to learn them I have to understand where they come from, and so in these two subjects it was very much so we just understand this and learn this to go onto the next stage.*

This student was explaining why she did not take science 'A' levels. She disliked science and she disliked science because she did not understand it.

When this was developed further using secondary school science practical equipment she said the following:

> *ww: Science was very it was very ok so you learn your table. What was that table... well it was learn that and do your experiment well write out your method of your experiment, your results and your conclusion. It was basically learn, learn, learn and I never really understood to be quite honest.*

She describes her science experimentation as basically following set procedures. These procedures had not meaning and she didn't understand why she was following these procedures or what science they were illustrating. Thus, it is not really surprising that when a rubber band with a weight attached is placed in front of her, she describes an experiment, but does not know that the experiment may be used to illustrate the forces on the rubber band.

Further this is not the only student interviewed that had some concerns about their understanding in science.

> *ff: I went to biology and she said Charlotte don't do it you just wouldn't cope and I was like OK Miss I won't do it then. She sort of influenced me more.. I don't know.. whether I should or shouldn't have done it.*

In this quotation the key words are you 'just wouldn't cope'. This might suggest that this student may have difficulties understanding science. This point is brought out further in other parts of the interview. For example, later the interviewee states that:

> *ff: .... you ended up with loads and loads of pieces of paper and you shoved them in your bag... it was OK but you didn't really understand what you were supposed to be doing.*

This particular student was one of the few from those interviewed that actually did take science 'A' levels. Even so she still felt insecure in her understanding and abilities in science.

The following student states early on in the interview that there was a lack of understanding in science. The student further goes on to describe how this lack of understanding negatively effected the proceedings in practical science lessons where the students are working in groups.

> *ii: There is going to be someone who is going to take over the experiment and there is likely to be someone who doesn't know what is going on at all and sits on the edge. So I think that some people can end up being completely flunked..*

4.2.2.1 Feeling unable to do science

Further, other students whilst not mentioning not understanding directly did mention that they felt unable to do science. These lack of abilities are related to the actual science itself in many cases and may support the idea that these

students did not understand science. For example, interviewee kk said the following:

> *kk: no I never even thought that I'd pass GCSE then.. So I was at one point contemplating doing biology and I was told that it had a lot of chemistry in it and that put us straight off.*

For this interviewee, a major aim as to achieve reasonable results in her examinations. As she didn't feel confident in her abilities to do this, she felt unable to take science at A level.

> *jj: That was physics I was very weak at.. I thought that I'd drop that a very low mark in the first two physics.*

Similarly to the above interviewee, jj measured her ability based upon the marks she achieved in tests. These were low so she felt unable to do science.

> *oo:.., because chemistry I had to work very hard at to... Basically I learnt my GCSE chemistry off like a parrot.... Parrot fashion...*

This student felt obligated to learn science like a parrot. That is she had to repeat things over and over in order to learn it. She felt she had to do this because she was unable to learn it any other way. Thus, she felt unable to learn science in a reasonable way.

tt: It was very much as it has been mentioned have a set experiment dissolving or heating water and it would be a get the results and then you get something drawn on the board and then this is how it should look if it agreed it did and if it didn't then you'd done it wrong. The result was that you wrote down what was on the board.

This quotation is interesting in that this student was expected to do science experiments. When she did these experiments, her results were always considered incorrect. Thus rather than writing down the experiment and doing the experiment to the best of her ability, this student simply waited for the teacher to write down the 'correct' results and then copied.

4.2.2.2 There was something wrong with the science

vv: ..in secondary school yeah . Mainly because they made it very interesting we weren't ever in science classes. I think it was maybe because it was that bit different. We weren't ever sat in rows, reading or listening or dictation. It was all sorts of things going on, and I think that the teachers for the two subjects that I chose especially. The teachers stopped it from being monotonous.

This student was asked about whether she felt science was taught well or not. She replies that she did and further adds that if it had not been taught well it would have been monotonous. Whether she means that science is monotonous or just any subject is not clear from this quotation along. When the background of the student is taken into account (someone who enjoys education), it is likely that she is talking about the science.

ll: A lot of it is this is this and you are not really told why and you are not told to question it.

This student felt she didn't understand science, as there is something wrong with the science. The student feels that they ought to have been told why things occur and been allowed to raise questions about the science that was being presented to them. Instead, they were expected to accept what they were told without understanding it.

Whilst the main response from those interviewed about their feelings about science was one of dislike and lack of understanding, some students in parts of their interviews did express a liking and understanding of science. Some examples of these will now be presented to the reader.

4.2.3 'I like science'

Of those interviewed, some students interviewed did express a liking of science. Five of those interviewed showed aspects of a liking of science to some extent.

The next quotation was taken from a student who felt that she was in general an 'arty person' and that was generally why she chose to study the arts rather than science subjects. However, she did express some liking for sciences.

uu: GCSE was quite interesting. Biology was quite interesting. One stage I thought that perhaps I'd like to do it for A-level. Physics we had one amazing teacher and one bad teacher and chemistry was quite boring.

There are some positive aspects mentioned here about her science lessons. So perhaps for this student it was not that she disliked science as such, rather that she liked other subjects more.

The following quotation is taken from a student, who felt very pressured in examinations.

> *ss:... I did a combined science and I really enjoyed that because we did sort of do separate physics, biology and chemistry of modules that was quite good.*

The student feels happier with the science as it is modular. She means that rather than one big test at the end, there are many smaller tests given throughout the course. Thus, this particular student felt less pressured, so she enjoyed the science more.

4.2.4 'Science is understandable'

Of all the possible categories into which to place quotations within interviews, this was probably the most difficult to define. Not all students mentioned understanding in the interviews. Further, those that did tended to state that they didn't understand school science. Of those interviewed, I felt that there were only really two students who felt confident in what they knew in science. The following quotation is taken from a student who had returned to education after a break and had done this through an 'ACCESS' course.

tt: The ACCESS course is basically condensed A level I suppose so it was a lot of theory and practical work. So it was basically what equations are for and how to use the equations. Basically it is showing you how to do something and then giving you some questions out of a book. So there was basically a lot of maths even in physics. That is much how it is here where you are doing a lot of experiments and you start from the real basics.. so in a way from what I remember it is pretty similar to school. I did a few experiments but not a great deal. It was mainly just the blackboard.

The student describes the course and even mentions the condensed nature of the course, in spite of this; the student does not mention that there was any lack of understanding. Further when it talking about examinations in science, the student says that:

tt: The exams on the ACCESS course ...I enjoyed the physics and I was quite confident in physics, and computing I was quite confident at passing that.

So this student does not appear worried about a lack of understanding in science that might negatively effect examination results.

The second student did acknowledge that science is a difficult subject to understand. However, the student says that:

cc: I always found science was easier than English so I prefer maths whereas English is a bit arty. Whereas, with science well maths you could always come up with an answer.

The student also had extra science lessons to overcome these difficulties. Further, at times the student found the lessons 'pointless' and 'dictatorial' in nature, which did not help in understanding. Thus on balance there is a feeling that this students feels that science is understandable.

4.3 So are students' perceptions of dislike for science and lack of understanding in it related?

Within the interviews, the students do to a limited extent relate these perceptions. For example, in the quotation below the student was asked the general question 'what about science?' This was during the first section of the interview where we were discussing choices for 'A' level. This was the response:

ii: I never liked physics. I think that that was partly to do with the teacher who wasn't very understanding. If she explained something then you didn't understand it.

The student relates disliking science to the physics teacher who was unable to explain the science in an understandable manner.

Further, this is not the only quotation that relates dislike of science to lack of understanding. The next quotation is taken from a student who was discussing the science practical equipment presented.

kk: I've always been a bit nervous, especially with science, as I've always found it difficult to understand.

The student expresses dislike of science in terms of being nervous of it and relates this to not understanding science.

As well as these straightforward suggestions that dislike is related to not understanding, there are some less obvious quotations in which students possibly suggest a relationship between dislike and lack of understanding. For example the next quotation the student was talking about subjects that were definitely not going to be taken.

vv: definitely didn't want to take science mainly because ..... people seem to presume that it is going to be very hard to do .

This quotation may be interpreted as a relationship between dislike and lack of understanding, if it is acceptable that 'definitely didn't want to take science' equates to disliking science and 'it is going to be very hard to do' equates to very hard to understand.

Other possible suggestions of a relationship include this quotation taken from a student discussing possible career choices. The student is talking about not following a science career path. The student states:

pp: I think it was important for me to do the subjects I enjoyed and that I was generally a bit better at than struggling at something I didn't enjoy doing.

This may possibly relate dislike with lack of understanding if 'didn't enjoy' indicates dislike and 'struggling at' indicates lack of understanding.

It must be mentioned that these quotations do not show a relationship between dislike and lack of understanding, as the quotations are only individual cases. However, it is interesting that in some of these quotations the students suggest that they dislike science because they don't understand it. Further, it is interesting to raise the question of a possible relationship and explore if possible the type of relationship. Moreover if the quotations are considered with the literature a discrepancy arises. The literature suggests that students don't understand science because they dislike it.

4.4 Summary for the first set of interviews

The results from the first set of interviews are open to personal interpretation. The hope is that some flavour of the interviews has been presented to the reader. That flavour being that these B.Ed. students are reasonably representative of a group of students in the UK who have perceptions of secondary school science. Further of those interviewed, most expressed a dislike and a lack of understanding of secondary school science. The students' dislike of science appears complex in that a number of interrelated factors are apparent. Thus, students express their dislike in terms of the science teachers, science's bad image, and the way that science is taught. When exploring the students' lack of understanding they said that they did not understand science and had concerns about their abilities in this subject and that something was wrong with the science itself.

When referring back to the literature review it is seen that these are all areas that were described there. So these interviews provide support for the idea that students dislike and don't understand science. Further, they support the raising of the question 'Are students' dislike of science and lack of Understanding related?'

Having said this, there were some limitations that did appear in the data. Firstly, some of the students did have problems remembering their secondary school science. Two of those interviewed mentioned that they had difficulties remembering it. Thus, the data provided does have limits as to its detail. There is not much information about the possible relationship between students' dislike of science and their lack of understanding of it.

Further, those interviewed did not truly represent the whole of the B.Ed. group, as they were volunteers rather than random choices. Those who did volunteer were those who wanted to talk about their past experiences of secondary school science. Thus, one could argue that a more positive view of it is being presented. The literature suggests that it is likely that almost no students understand science, whereas two were found that feel themselves to have an understanding of it.

Finally, even with the emphasis placed upon secondary school science, some students still wanted to talk about primary school science and their recent experiences of science at University occasionally. Thus, there is a risk with

some students, that they may occasionally have been expressing negative perceptions of their university science rather than their secondary science.

4.4.1 The results from the second set of interviews

As a result of the first set of interviews it was decided to implement a second set of interviews. These interviews were to be implemented after the first year of the students' science University course. The idea was to explore the relationship between the students' dislike of science and lack of understanding of it. During their first year at University the students' experienced a science course based upon an improved science curriculum. This improved curriculum presented a science that was thought to be more understandable to the students. It was not aimed at making it more likeable by them (at least not intentionally). Two lecturers Dr P. M. Johnson and Prof R. Gott implemented the intervention.

The questions asked in the second interview, were developed with regard to the data collected from the first set. This is why the questions asked for this interview are presented here, rather than with those asked in the first interview. The questions asked were the following:

Table 8 Key questions from the second interview

a) How do you feel about science? b) Do you think that you could do /could not do science? c) Is there one bit of science that you are particularly happy/sad about? d) Do you think that you feel positive or negative about this? (Gravity, combustion) e) Why didn't you understand these ideas before, do you think? f) Would you want to do more science now, if you could?

The questions were asked in a similar manner to those asked in the first set of interviews and to the same students. Thus, there was a trial before the major implementation, the interviews were recorded with the students' consent and transcribed, and those who volunteered were re-invited for a second interview.

A difference was apparent in the length of the interviews. Those in the first interview lasted approximately one hour whilst those in the second interview lasted fifteen to twenty minutes. Thus, the first interviews were more open than the second highly-focused interviews. Another difference is that in the first interviews the students were placed into categories by analysing what students said, whilst in the second interview the aim is more to allow the students to choose an appropriate category for themselves. Before presenting the results from the categorization of the students, an illustration of the types of answers given by the students will be presented.

4.4.2 How do you feel about science now?

For many of the students the answer to this question was positive. For example, hh says the following:

> *hh: yeah I like it. I think I prefer biology more than chemistry and physics if you split it up into subjects.*

She clearly states that she likes science. Further, she clarifies this by dividing the subjects into biology, chemistry and physics and placing these subjects in order.

She does not say if this is any different from secondary school science. There are examples of this from other transcriptions. ss gives the following answer to this question:

> *ss: well its different here from what I did at school. I think that I really wanted to do it because I didn't do it at A-level.*

The student says it is different from when she was at school. She felt that it was something that she missed out on at school. So she is studying it now. Having established that it was different for this student, it would be an idea to see if they any student is able to elaborate further on possible differences.

Student rr elaborates on this difference in the following quotation:

rr: I feel better than I did at school because I now know how to think rather than just giving a set answer or rather than being asked to copy out of a book and being asked to revise it for an exam whereas here. Whereas now here we are asked to think about things that have happened and we can carry out experiments by ourselves where as in school it consisted more of the teacher showing us the experiment and we just watching it and taking down notes.

The student first states that she has more positive feelings about science than at school. She says that she is more positive about science as she feels that she has a much more active role to play in the University science. An alternative difference is mentioned by vv, who states that:

vv: From the last time very different it feels like what I should have learnt at school.

Whilst it is not clear exactly what this means, it does raise some questions. For example, 'Was there something wrong with the secondary school science?'

If must not be forgotten that so far, the positive answers have been explored. The less positive and negative answers have not been explored. Some students felt no change had taken place. For example, BB states:

bb: The same as I did before. I'm a very arty person so...

This student just feels that there are science people and arts people and that she is an arts person. Further, this has not changed.

There was only one other student that felt her feelings had not changed, and no student stated that her feelings were worse than at school. So there is a need now to explore these differences further. The next question explores the students' perceptions of their abilities in science.

4.4.3 Do you think that you could do / could not do science?

Many of the students gave positive answers to this question. In the interview with vv the following response was given very quickly:

vv: yes definitely.

Other students qualified their answers. For example, ll says:

ll: I could say I could do parts of it. I'm more confident.

Further, this student equated this limited ability with an improved confidence. There were similar comments made about ability to do science. In one transcription the student said that she felt that she could do science, but she didn't do want to do science simply because she was not interested in it. To find out if this feeling was always the same for the students, a follow up question was asked. I asked, 'Have you ever thought that you could not do science?' When this question was asked to vv, vv gave the following response:

vv: I did when I was much younger when I was doing GCSEs. I dropped, I had to do two sciences and dropped biology and thought it was totally impossible and couldn't do it at all.

Moreover not only does the student state that she could not do science, she goes further. She says that it is an impossible subject. The time when she felt this was when she was in secondary school. For the majority of students there was a time when they felt that they couldn't do science and this time was before they had come to University. kk in her interview made a further point that was interesting. She stated that she could not do it before because:

kk: Nothing seemed to fit together properly it all seemed to be just a different language.

This student does not point to problems with teachers or the way that science was taught, rather it was the science itself. In this situation, the student mentions that the science does not seem to fit together. This is almost as if she is describing trying to solve a difficult jigsaw puzzle, with there being bits of science that have to be fitted together. dd also mentioned 'bits of science'. She said:

dd: Lots of times. When I've thought well there has just been a concept introduced and I just thought that I'd never have got the hang of it. It has been broken down into bits and this works.

I was actually asking her if she had ever felt science was an impossible subject. In this quotation, she goes further and describes these bits as being too big.

Thus to make the science less impossible the bits must be broken down into smaller bits. To add to this idea of science coming in bits, dd mentioned that she felt that science alternated between the two for her. Thus there were times when she was asked questions in science, which she felt were impossible to answer and time when she felt she knew the answer.

As well as students who felt the science was a subject that couldn't be done, there were those who felt that they always could do science or that this was not part of a change in feeling towards science. For example, AA stated that:

> *aa: I'm not sure that it was that I couldn't do science or I just didn't want to do it before. I don't think that you can't do it at A-level anyway.*

Thus, you could take science for A-levels, if that was what you wanted. However, when she was asked whether she had felt science was an impossible subject, she stated that it was when she was at school. It was impossible in that she was not given the opportunity to learn it. Thus, there are perhaps two levels of thinking: a personal level and a more general level. There was only one other instance in which the student disagreed with finding science impossible. The student said that rather than it being impossible, it was difficult.

4.4.4 Is there one bit of science that you are particularly happy about?

During this section of the interview, the students were asked about particular bits that they found enjoyable. There were a number of views presented about the science and what made it particularly enjoyable for the student.

One answer was that there was happiness about all the science. For example, vv says the following:

> *vv: I'm happy about anything that seems to make sense to me. Anything that I can see and link to the everyday world to me. That is something that I'm very happy with the science course.*

Some students similarly to the first interview split science up into biology, chemistry, and physics. Those that did this, tended to be happier with biology than chemistry and physics. This again is similar to the finding in the first interview. For example, ff said this:

> *ff: I'm not sure I've always been happy about biology. I think the physics, I'm more happy of because of doing this. This makes it more complicated than you think because at college it is more it is just that now it is why does it happen.*

Other students expressed a liking for courses of the science that they had experienced at University. For example, oo mentions the matter and interactions course:

oo: yes the course last year the matter and interactions course kind of helped a lot. I mean there were things where... Phil was telling us things where opposite to what I was being taught kind of thing. They made things look a lot clearer, much.

Finally, some students pointed to particular aspects with their University course that they were happy about. For example, one student mentioned being happy about 'atoms and molecules'.

In looking back upon the quotations mentioned it is worthwhile considering the reasons stated by the students as to why they felt happier about the science that they mentioned. vv feels the science relates more to everyday life and that it makes sense. ff mentions that it is because of considering 'why'. Finally, oo says that is because of the lecturer making the science clearer.

As well as those who did express happiness for certain aspects of science, there were a few who were not happy about any part of science, and a few who simply had not thought about it before and so did not have an answer.

Thus, it was useful to give the students specific areas to talk about to help them think about their science and experiences and as a memory aid. Further, those students that had the answers, mentioned above, interpreted the question in different ways. So by being more specific more comparisons should be made between students.

4.4.5 *Do you think that you feel positive or negative about this? (Gravity, combustion)*

During this section, the focus is upon the ideas of gravity and combustion presented to the students within their lectures. Gravity was illustrated using a rubber band and a weight, and combustion using a lit candle.

Further, their understanding is being considered. Thus, what is occurring is an exploration of the possibility of a relationship between feeling happy and understanding. It has to be emphasised at this point that it is the perceptions of their understanding that is being considered rather than their actual understanding.

The vast majority of the students were happy to talk about the apparatus. They talked keenly about the apparatus. The following quotations are examples of some of the ideas mentioned when talking about the rubber band and the weight.

> *aa: about the forces and the gravity and the electric forces inside the elastic band, the attractions and repulsions.*

What exactly the student means by electric forces within the band is not mentioned. She feels confident that she has some understanding of this topic and uses both attraction and repulsion to describe forces.

In the interview with bb, the student felt 'indifferent' about the equipment. In spite of this she still described in reasonable detail what was occurring with the rubber band. She said:

bb: yes I do I just remember what is going on here. It is about the particles that are attracting one another in the elastic band.

She is using the idea of particles and attraction to explain the rubber band. These are both complex issues, so she is displaying some confidence in her abilities to understand science ideas.

Similar results were obtained when the students talked about the lit candle. Here again students talked keenly about some complex scientific ideas. For example, gg says the following:

gg: .... I think like we did last year two gases brought together and a reaction because there is a flame and what happens when the flame goes out.

To some extent with this one, it may be said that she is hesitant in that she pauses and then states that she is thinking. An alternative possibility is that she realises that this situation is far from being simple and straightforward and does require some thought to understand.

Whilst the students responses would in no way be construed as an explanation for the ideas raised within the lit candle it was possible to say that the students did appear confident that they were progressing in their learning and were themselves developing ways to tackling the ideas. In the following quotation the student does not attempt to mention any science ideas, rather she suggests appropriate questions to ask:

ff: when you start to think of how does it burn.. you light it and supply heat to the wick then it is like well how does it keep burning ? Why does the wax disappear? And what's formed? As you bring together the ideas it was all a bit complicated. How it actually starts. Once the reaction is going then you can understand it. How it goes.

The student says that the ideas are complicated and then begins to outline a process to start to understand it.

In addition to mentioning, the sort of ideas illustrated students were also prepared to talk about some of the difficulties they felt had been encountered.

The following examples concern the elastic band and the weight. Previously this student mentioned that the rubber band bounced around and then eventually came to a stop. The student also mentioned molecules. With reference to these ideas, ll says that:

ll: they were difficult. I understood the molecules inside the elastic band stretching and pulling together and pulled apart. But I didn't really understand why it came to a stand still eventually. Why is eventually arrives at there.

Essentially the student had problems answering the question 'Why does this occur?'

Similarly, kk is making a comment about the same set of equipment. The student is comparing what was known before coming to University with what is known now. The students mentions that:

> *kk: before hand you just knew that the elastic band stretched and ... but you didn't know why... I knew that it stretched because there was extra weight on the end, but not what was actually happening I don't think.*

The student mentions that again it was not known 'why'. Further, this 'why' is described in terms of 'what was actually happening'. It is difficult at this point to say what the student means. Perhaps in simple terms, the student was able to give an overview, but was unable to give a precise description.

So moving now onto the second set of equipment. Some comparisons need to be made to see if the students for these pieces of equipment said similar things. One similarity is evident in the transcription of the interview with tt. Tt was being asked 'What sort of areas were there that were confusing for you?' This was the response:

tt: What is actually happening. It is easy to say that there are lights and things and that you need a heat source to actually get it lit. Something along the lines that when the candle was blown out and placed near the wick and not touching it then the flame started again. Some of us... none of us had ever realised that you didn't have to touch the wick with the flames to get it a light again and what was going on there. The fact that things are being given off.

Similarly the student mentions that the confusing part is 'What is actually happening'. tt then expands upon this by giving and overview of a candle being lit and then goes into a fuller description. When listening to the student speak about this topic, the enthusiasm was really self-evident not only in what was said but the way it was said as well.

On the same topic of lighting a candle, dd says that there was a problem with 'why'. She said:

> *dd: We just took it for granted that when you put a match to a candle then it burns. And that is it. They never explained why.*

From the examples, given above an illustration has been made of the similarities of the things said by students about these two pieces of equipment. For some students there were also differences. One difference that did occur was that students felt that there were more problems learning the ideas concerned with the lit candle than those with the weights and elastic bands.

Comments are only possible with regard to the individual student's perceptions. The perceptions are more positive and students appear to think that they now understand or are getting to grips with science ideas. This was not occurring in secondary school. Having said this there was a small minority who felt that their understanding was unchanged, or that there were differences between the science courses, which makes a comparison difficult.

Those that felt their understanding had not changed felt that the University science course was a refresher course rather than anything new. So the student had learnt similar things at secondary school and university, but had forgotten it since secondary school and was now being reminded.

Those that stated that there were differences between science experienced at secondary school and University simply stated that they learnt science at school to pass GCSEs and other similar examinations. At University, they are learning science to pass a degree and to be able to teach it. So it is different, which makes comparisons difficult.

4.4.6 Why didn't you understand these ideas before do you think?

In this question, the students made comparisons between their experiences at secondary school and at University. Three major themes appeared in this section. They were that they did not understand science before in secondary school because: they did not have it explained to them, they were not encouraged to ask questions, and finally they memorized the science to pass exams.

For the first of these, ii says the following:

ii: no one even tried to explain that to me

This says more than not having things explained. It seems almost to this student that people such as teachers had given up trying to teach science to students. Science was impossible to explain to secondary school students and it was not worth trying. There is a feeling of anger from the student as well.

Perhaps the student feels angry because now some science has been explained and the student feels that this should have taken place in school as well. Further, there was not just one student who felt like this, but also a number of students. For example, uu similarly states:

uu: because they were never taught before, or I wasn't listening.

She does also add an alternative. She might have not been listening. In thinking about why a student might not listen, one possible reason for not listening is that what is being said does not make sense. Thus a circle is being formed. The teacher does not explain the science to the students, so the students do not listen. Secondly, the teachers do not bother to explain the science because the students are not listening.

The second theme was that the students were not given the opportunity to ask questions. oo says this about the topic:

oo: .... because you were not taught to ask questions.

This is a strong statement in that not only did students not ask questions; they were not taught how to ask questions. One interpretation of this is that not only must students be allowed to ask question they must also be taught what questions are appropriate. Along similar lines dd says:

dd: Well I suppose that the teachers didn't exactly teach you to question things. I just accepted that I never questioned that I never wanted to know anymore about it. So that is why I didn't understand it.

For dd, the student also 'just accepted' what was being said. They did not try to understand the science by questioning what was being said. In many ways, what the students are suggesting is a break down of communication between students and teachers. Thus, the students are not questioning and the teachers are not encouraging them to question.

The final theme is that students are not learning. They are memorising to pass exams. ss says as much:

> *ss: You just really memorised things for the exam.*

This particular student went on to suggest that students did this, as they did not have time to fully look into what was being presented to them. rr suggested another alternative:

> *rr:... the lessons didn't follow on from one another and it was just one random thing after another so it wasn't a case of whether we understood it or not. Rather having to do it and that's it now. And then we get through the exams at the end of the year.*

rr suggests simply that the science did not fit together. Thus, it was impossible to understand and understanding science was not an option. It was just a matter of going through the motions and passing the exams.

As well as these three major themes, students did mention other ideas. One of these was simply that they did not understand the science, as they did not want to understand it. For example, ww says that:

ww: I had a real negative view about it.

The student had no interest in science. She disliked science, so she didn't want to understand science.

The results from the asking of this particular question do not suggest any real reasons for not understanding science, nor do they suggest that they understand science now. What they do suggest is that when at school they felt that they didn't understand it. They express this lack of understanding in terms of: not having it explained, not questioning and the science not making sense. Whilst it is not possible to suggest that these students understand science now, it is possible to suggest that they feel that they understand it better. Finally, a relationship is being suggested between allowing students to learn science, and students wanting to learn science.

4.5 Allowing the students to be placed into categories

By considering specific quotations from specific transcriptions it is possible to build up a an idea as to whether the student perceives themselves as disliking or liking science, and whether the student perceives the science as being understandable or not understandable. Thus, each student's transcript may be placed into four major possible categories. They are: dislike / don't understand, dislike / understand, like / don't understand, and finally like / understand. In addition to this is the possibility that a transcript may not fit into any of these categories.

4.5.1 *An example of the gg transcription being placed into the category of dislike / understand*

The placing of transcriptions into this category was a little more difficult. The students were open about whether they felt an understanding or lack or understanding, but were not so willing to discuss whether they liked science or not. One possible reason for this might be that the course was compulsory. Thus it did not really matter whether a subject was liked or disliked, it was just a matter of getting on with it. One indication as to the students' dislike was found when they were asked if they wanted to do more science. For once the compulsory science is completed, the students do have the opportunity to do additional science or not.

The gg transcription was placed in this category due to the interpretation of the following quotations:

Dislike:

> *I: Would you want to do more science now, if you could?*
>
> *gg: I don't think so.*

Understand:

> *I: OK. Did you have any problems understanding these ideas?*
>
> *gg: I don't think so they were sometimes complicated to understand but I never really had any problems with them.*

In addition to the quotation concerning dislike, there were extra indications as to the student's dislike of science. She was presented with two pieces of equipment. The responses to questions about the scientific ideas were short and precise. For example, the student at this stage was presented with a rubber band with a weight attached to it. This is what was said,

I: What sort of ideas would you use this to illustrate?

gg: the forces in the elastic band that is what we did last year.

I: anything else?

gg: no that is all.

When talking to other students about this equipment, responses tended to be much more open and longer. It might have been that she simply was not enjoying the interview. If this was the case through, then why did she volunteer to talk to me again?

The quotation listed above as an example of the student understanding science is supported by a number of other quotations within the interview. This is illustrated in the following extract:

I: Did you have any difficulties understanding these ideas?

gg: No I don't think so.

The student was talking about candles.

4.5.2 *An example of a transcription ww being placed into the category of like / understand*

The placing of this class into that of like / understand is straightforward. There are many examples within the transcript of the student indicating that she perceives herself as being able and interested in science. Some of the many are given below:

Like:

> *ww: It is brilliant this subject. Even at the beginning of last year I thought I'm not going to be able to cope with this subject. But then you realise that you can. You think this is quite difficult and then you work through it. It does come out OK in the end.*
>
> *ww I'm just more happy about the basic principles of atoms and molecules, just the basics of everything (attractions and repulsions). I mean I just didn't know anything about that before. So everything you can build on from those principles.*
>
> *ww: It is interesting because you can apply science to things that you know and understand what is going on. So that you can actually relate to stuff*

Understand:

> *ww: I understand it much better since the matter and interactions course.*

ww straight away I wouldn't actually think of the actual make up of the rubber band. I would think of gravity and that was it. I would just think of the gravity and that was it. I would just think that the band holds it back and that is it (reference to secondary school science).

The student expresses her like for science in the above quotations in terms of brilliance, happiness and interest in the subject. Further, some of this like of science comes from actually being able to do the science. That is, understand it.

In the understanding section, she attributes this understanding directly to the matter and interactions course. Further, she goes onto to express this understanding of science by explaining some of the principles she has learnt with reference to the rubber band and weight equipment.

When comparing this interview with the previous interview, one obvious difference is the whole way the student talks about the science. In the second interview, the student talks at greater length and with much more enthusiasm.

4.6 Conclusion to the second set of interviews

When all the transcripts were placed into categories, the following results were obtained:

Table 9 Categories of students found in the second interview

Category	**Number of students placed in category**
dislike / don't understand	0
like / don't understand	0
dislike / understand	9
like / understand	12
other	0

In placing the students' transcripts into categories, a number of issues arise. They are that:

- No students were placed into the category of dislike / don't understand.
- No students were placed into the category of like / don't understand,
- The students now appear much more positive about science.

4.7 Discussion of the results

When a comparison between the first set of interviews is made and the second set of interviews. It may be said that the students in the first set of interviews, with very few exceptions, expressed a dislike of science, and a perception that science was not understandable. In the second set of interviews, students were categorised into two major categories. They are like / understand, and dislike / understand. Thus, two major changes have occurred from the first to second interviews. They are a change from dislike / don't understand to like / understand and a change from dislike / don't understand to dislike / understand.

4.7.1 Possible Problems with the results

Further a number of question also arise:

- To what extent is the comparison, made between the two sets of interview, valid?

- Is there any evidence to support the idea that this change may be due to the intervention that was experienced?

4.7.2 To what extent is the comparison, made between the two sets of interview, valid?

In considering the validity of a comparison between the two sets of interviews, some limitations do become obvious.

Firstly, the conditions between the first and second interviews are different. The most obvious difference is that the questions asked in the first set of interviews were different from the second set. Another difference is in the length of time spent on the interviews. The first set of interviews lasted an hour whilst the second set lasted approximately a quarter of an hour.

A second problem is that the analysis of the two sets of data was not undertaken independently. Thus the first set of data was analysed then the second, but by the same person. This being the case, the first set of results may have effected to some extent the second set.

My personal feeling with this is that the second set of analysis was definitely effected by the first. However, the effect was a positive one rather than a negative one. This is as during the first set of interviews, I felt somewhat

overwhelmed. I had so much data to look at and much of the data was not relevant to the research being undertaken. There was also the feeling that there was some relevant data there if only I could get at it. In the analysis of the second set of interviews the process was much more refined. I felt that much more of the data was more relevant and the analysis was much more focused.

4.7.3 Is there any evidence to support the idea that this change may be due to the intervention that was experienced?

A stated aim of the intervention was to improve the students' understanding of science. The results from the second set of interviews suggest that students perceive themselves as having more understanding of it. Further, many of the students suggest that the science experienced whilst at University was not the same as the science experienced whilst at secondary school. Exact differences are not expressed. However, students do say that they now know 'why' things happen rather than having an inadequate description of what was occurring.

If it is acceptable to suggest that the students' perceptions reflect an actual improved understanding then it is possible that this improved understanding is a result of the intervention (whose aim was to improve students' understanding of science).

Chapter 5

DISCUSSION AND CONCLUSIONS

Does the Nature of science education cause female students' disaffection with science?

5 Introduction to the discussion

The intention of this section is to draw together all the major points made within the previous sections. To do this a brief summary will be given outlining the main points of each section of the thesis. Thus, the points raised within the introduction will be raised followed by those in the literature review and so on. The reason for this is to remind the reader of the points without having to refer back to individual paragraphs from previous pages. Further there is a need to discuss the strengths and weakness of the materials presented.

Following this stage, the possible causes for students' disaffection with science (they dislike it) will be investigated. What is being looked into is the possibility that the nature of science education (a major part of which is lack of understanding) causes this disaffection with it.

5.1 Summary of what has been said so far and some reflections

During the introduction of the thesis, two major ideas are presented to the reader. Firstly students do not like science and secondly that they do not understand it. The dislike for science is initially presented in the form of

figures of student enrolment in science A-levels. The fact that students don't understand science is presented with reference to key pieces of research into students understanding of science whilst at secondary school.

What the enrolment figures show, is to some extent open to debate. Certain parts of science (physics and chemistry) do appear to be unpopular when compared to other subjects. Further physics unpopularity seems to be increasing. Another concern is that students taking all science and maths subjects are decreasing. This is of concern, as students who study only science and math tend to become scientists. A need is present for scientists within the UK's work force. With regard to students understanding, a number of pieces of research highlight the need for students to understand science. The understanding is not of highly complex scientific theories, but for basic scientific ideas that constitute a reasonable grasp of science. Further these ideas should be useful to students after they leave school in their everyday lives.

In the literature review, the major aim is to provide support for the idea that secondary school students dislike science and don't understand it. Students' dislike of science is supported by careful examination of a number of pieces of research in certain areas. The main areas that have been covered are those of secondary school science; being sex biased, being irrelevant, having a poor image, being an academic subject, being culturally biased and involving pressure from peers and teacher not to learn it. Students' lack of understanding for science is described in terms of six science areas. The areas

are for physics gravity and forces, for chemistry particle theory and the process of combustion, and for biology skeletons and animals.

The lines of thought presented for students disliking science are briefly given below. Science is sex biased, as school science lessons are masculine and authoritarian. This leads to female students disliking science. These biases are irrelevant to many students, as school science does not adapt to the needs of individual students. So many students dislike science, as it is irrelevant to them. Science has a poor image as scientists are seen as unpopular, earning little money and being misrepresented. Many students do not want to be unpopular, earn little money and be misrepresented. So again, they dislike science. Science is academic in that a major aim of much school science is to produce research scientists. Many students do not want to be research scientists. Thus, they dislike it. Science is culturally biased; as those who study it tend to come from cultures, where science is part not only of their school lives but also of their home lives as well. People who are not part of the scientific culture have difficulty adapting to it. Thus, they dislike science. Finally there are pressure placed upon students not learn science by their peers and teachers. Many students prefer to conform to these pressures rather than rebel. Therefore, they dislike science too.

In effect, there is a web of various pieces of literature that talks about various aspects of the students' dislike of science. These parts are all interconnected to some extent. For example, many female students find science irrelevant as well as being sex biased. The parts presented are not all those found in

research literature to suggest that science is disliked. They are however major parts. Further some of the other parts are referenced (parental influences and media effects), so that should the reader require further investigation into these then there is a starting point.

For each area of students' lack of understanding a brief description of the findings are given for those pieces of research being reviewed. The results make for a depressing picture of students understanding. With papers suggesting that, students have little or no understanding of these topics. Further, little or no improvement is seen in the students' progress through secondary school. It must be mentioned that this is not an attempt to blame students. It rather seems that school science lessons in the topics concerned are ineffective at allowing students to understand basic scientific ideas. The literature presented ranges from recent research to that from the 1980's. During that time, little seems to have changed in the fact that students did not understand it then and they do not understand it now. Perhaps through there is more awareness of students' own ideas about science. These ideas in themselves though are not the same as those in held by scientists. Those areas reviewed cover a range of basic science ideas and whilst they do not cover all common science ideas, many references are made to many other areas not covered in the literature review. Thus, the literature does tend to suggest that students have little understanding of much of the science presented at secondary school. Further, that which they do understand may come from their own personal experiences outside school.

So at this point, there is the fact that students possibly dislike secondary school science and they don't understand it. The aim of the thesis now changes to investigating dislike and lack of understanding in a suitable sample. The sample was a group of first year Bachelor of Education students. The sample was to be investigated using a questionnaire and an interview. Both of these instruments were trialled before being applied. The questionnaire considered the students' educational history and the interview looked at their perceptions of secondary school science. As well as the actual questions asked in the interviews a number of props were used. One major reason that interviews were used was that the sample was articulate and thus expression of feelings and information through language was not likely to be a problem. Those interviewed were volunteers, so few ethical problems arose. However, some problems may have occurred in how representative those interviewed were of the whole group. It may be that a slightly more positive view of science was presented by those interviewed than of the whole group.

After the application of the interview, the data was analysed. This occurred by cross-referencing what the students said with the topics raised in the literature review (dislike, and lack of understanding). In addition to this, more positive views of secondary school science were not totally overlooked. On a personal note, I felt quite disheartened by the consistently negative perceptions that these students expressed. Further, it was decided that there was an opportunity to interview these students again to find out if the perceptions of science had changed as a result of their first year at University.

Thus, a new interview schedule was trialled and developed based upon obtaining students current perceptions of science.

This new interview focussed students' perceptions of dislike / like of science and lack of understanding / understanding of it. Further at this point some attention was paid to what might have caused any changes seen and if the was a relationship between lack of understanding and dislike for science. It has also to be taken into consideration that much of the University science course was aimed at allowing students to understand science. From the results obtained the students were categorised into four major groups. They were dislike / don't understand, like / don't understand, dislike / understand, and like / understand. The main findings of the second interview were that students fitted into the categories of dislike / understand and like / understand. None fitted into the categories of like / don't understand and dislike / don't understand. Thus a positive change had occurred.

1. Some reflections on possible strength and weaknesses of the research

The literature used within the literature review is of a reasonable quality in that the references used are from published authors, and come from journals, books, international conferences and institutions that are well established and use established procedures to ensure the quality of published materials. The pieces of literature were found by exploring recently published journals held within the Durham University, considering references found in individual pieces of literature, and examining computerised data bases of research literature.

A major problem with the research on students' dislike of science was the vast quantities of materials and the interconnectedness of these materials. Within the literature itself, the topics covered in this section are often described as being a web. This being so, I often felt like a fly trapped within a web rather than the spider organizing the web. The topics covered in the students' disliking of science do not include all parts, but they do cover the main parts and those of major interest to this thesis. For example, one area that was not fully explored was that of the media. However, references are given that should give the enthusiastic reader and start on further investigations.

In many ways due to the vast nature of the topic of students' dislike of science, decisions had to be made as to how much to include so that each part of their dislike can be covered in a satisfactory manner and which parts to leave out. To try and cover all the parts would have meant that each part could not have been covered to a reasonable amount of depth.

With regard to the methods used to obtain data from the students, little more is given to the reader other than a description of how data was collected. Little comment is made to try and improve upon research methodologies presented within similar pieces of research. Thus rather than creating a totally new methodology, the aim was simply to use the best methods available to collect the required data. To be quite honest there was no real need to improve the methods, as they proved satisfactory in providing a wealth of valid data. It is difficult to see how the validity of the data could be improved. Those interviewed, were interviewed with respect to secondary school

science, were volunteers and were no longer part of the secondary school culture, peer pressures or teacher expectations, having recently left.

The results from the first interview show many examples of students' perceptions of disliking secondary school science and not understanding it. This provides support to the literature review in saying that many students dislike and don't understand science.

With respect to the second interview and the intervention, there are limitations. These results are not generalisable. Simply because a intervention may possibly have attributed to a positive change in students' perceptions of science whilst undergoing a B.Ed. course does not mean that a similar attempt would work when applied to secondary school students. However, it does offer some hope that a similar intervention developed from that applied here might. Further, it does not suggest that such an intervention would not alter secondary students' perceptions.

5.2 The change within the B.Ed students' Perceptions

This section is really the main focus of the discussion chapter. The aim is to discuss and raise the following questions with regard to the change that took place within the B.Ed. students.

I. What changes occurred to the B.Ed students' perceptions?

II. What possibly caused these changes in perception?

The raising of the first question involves the considering of the groups that the students were likely to have been in when originally interviewed and the groups that the students were categorised into after the second interview.

The second question is raised and considered by reflecting on the changes that have taken place to students since leaving secondary school and going to University with regard to the issues mentioned earlier in the thesis.

5.2.1 What changes do the interview results suggest to the B.Ed students' perceptions?

The changes in B.Ed students' perceptions can be shown with the aid of a diagram. In the diagram there are two possible routes of going from Dislike / don't understand to like / understand.

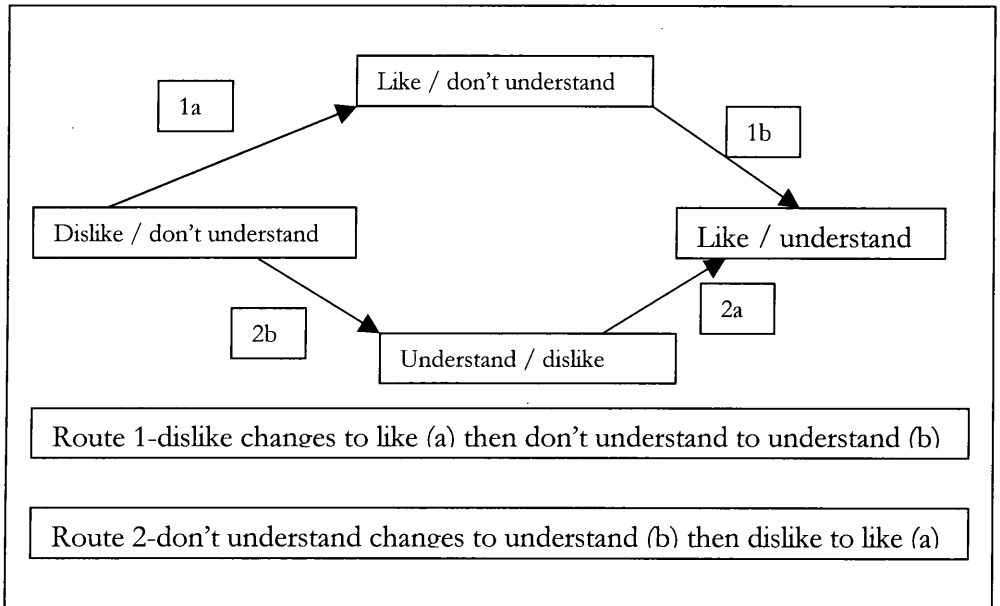

Figure 1 Changes of students' perceptions

They are using route 1 and route 2.

From the first set of interviews, students expressed a dislike for secondary school science and the perception that they didn't understand it. With the results from the groupings from the second set of interviews students appear in the dislike / understand and the like / understand groups. They do not appear in the like / don't understand and dislike / don't understand group. In other words, the students expressed a perception of understanding. Further, some students liked science and some disliked it.

An assumption made so far is that secondary school science and the science experienced at University would be comparable. To some extent, they are comparable. Both are forms of science and similarities are seen in the topics. Thus in the science students experienced at University, two of the topics covered were forces and combustion. These are both topics that appear in the National Curriculum for England and Wales, so it would be expected that these topics would have appeared in the science that the students experienced whilst at secondary school. This being the situation then two changes in students' perceptions of science have been seen after having been at University for one year. They are; the change from disliking and not understanding science to understanding and disliking science, and the change from disliking and not understanding science to liking and understanding science. These changes are represented in the diagram above by change 2b, and 2b + 2a or 1a + 1b respectively.

For the change of 2b it has to be emphasised that these are the students perceptions of whether they don't understand or understand science. So it is

not possible to say that these students now understand parts of science. It is however possible to say that they perceive themselves as having more of an understanding in certain aspects of science. Further, it might be that the students feel more confident about their abilities in science.

For the change 2b + 2a or 1a + 1b, one consideration is which change is occurring or are both changes occurring. Now if only one change was occurring and the routes 1 and 2 took approximately the same time then the expectation would be that either an intermediate change of 1a or 2b would be seen. In this situation, an intermediate change of 2b is seen. So if the routes take the same time then this change is 2b + 2a and not 1a + 1b. If both routes are occurring then there must be differences in time for routes 1 and 2. To distinguish between these changes it would be necessary to perform a longitudinal study based around a series of interventions and assessments.

5.2.2 What possibly caused these changes in perception?

There are three major explanations for the changes in students' perceptions. Firstly that it is something to do with the students, secondly that it is something to do the change in conditions in which the learning is taking place, and thirdly that there has been a change in the learning of the science. The only other possibility is that the change in perceptions did not occur, as the interviews did not correctly assess the students' perceptions of science. Whilst this is a possibility, a number of steps were taken to validate the data collected. There seems little likelihood that the data is invalid. The major criticism of the methods used to collect the data might be that those

interviewed were not representative of the whole group. This was something about which I was concerned. In examining further additional evidence from end of course anonymous questionnaires, similar data was obtained to my own albeit in less depth and detail. Further a high proportion of the year-group that was my sample, volunteered to take the second year science classes. Thus, it is likely that to some extent the findings from those interviewed, whose perceptions towards science had changed, were representative.

So what possibly caused students' perception of science to change? One possibility is that the students were being reminded of the science that they had learnt at school. Thus, they were being 'refreshed'. Thus, they were given a second opportunity to learn and understand school science. They took on more of the science that they had not learnt in school, so gained a better understanding, which is why their perceptions of their understanding improved. Additionally it could be that students are now more mature. As the students have grown older, the students' thought processes have developed in ways that allow them to cope with larger amounts of possibly more complex information. So whilst at school they might not have been able to learn science due to inabilities that result from being immature. Now whilst at University they are mature and so more able to do so. Thus, they perceive themselves as having more understanding. This possibility was explored by Adey and Shayer (1994). Adey and Shayer attempted to increase secondary school students' thought processes to allow them to understand

more of the science being presented to them. The results from this intervention are inconclusive. None-the-less it is a possibility.

The second possibility is that something in the conditions in which the learning has taken place has changed. This change has caused their perceptions to improve. By looking at the reasons given in the literature for student disliking science at school, it may be that these reasons are not applicable to the conditions the students now find at University. The reasons given for students disliking science at school were sex bias, irrelevance, poor image, an academic subject, cultural bias, and negative peer pressures and teacher expectations. With regard to sex bias, the majority of students studying science as part of their B.Ed. courses are female so there is no bias. Further students may now see the science they are learning as being more relevant as it is part of their professional training to become primary school teachers. Whilst scientists and those who study science may have a poor image, this may not apply to these students, as they are to be primary school teachers. Thus, they may not mind this poor image that scientists have. The culture may also be one that is more in line with a learning science environment than that they experienced at school. For example, the facilities that Durham University has may be more extensive than those in their schools. For example, they may not have had such a range of books and reading materials. They may not have had access to computer systems and the worldwide web that are available to all Durham University students. Further Durham University is a long well established University founded

upon the traditional collegiate system similar to those of Oxford and Cambridge University. Thus the traditions and culture of the University are that of a community where the learning of science is acceptable. This acceptability of the learning of science may be reflected in the peer pressures and teachers expectations that students experience. Thus rather than negative pressures and expectations students may experience positive ones. Thus rather than disliking science as occurred in secondary school, students may actually experience a liking for science. This improved liking of science may lead to students learning science, which would mean more understanding of science and hence more positive perceptions of it.

The third and final possibility is that there is something within the lessons themselves that is effecting the students' perceptions. There seems to be two things within the lessons that could effect students' perceptions of science. These are; firstly the teachers themselves, and secondly the science that they are experiencing. It could be that the teachers are simply excellent teachers, adept at motivating and communicating science to their students. Certainly those teachers that do teach at Durham University could be considered as being well established and experienced in nature. Further OFSTED reports on teachers in the Education Department of Durham University suggest that the teaching students receive is of a high quality. The second point is that the science that students are experiencing is an improvement upon that experienced within secondary schools. This is in line with the aims of the curricula of the science courses at Durham University, science education

department. Further, much research has been undertaken into presenting a science that allows students to understand it. For example recent research undertaken by researchers at Durham University in this field includes; Gott & Johnson (1999), Johnson (1997 a, b), and Johnson (1998 a, b, c).

5.3 The Nature of Science Education: Does it cause female students' disaffection with science?

In the raising of this question, there are two frames of reference. They are the Bachelor of Education students and secondary school students. With regard to secondary school students care has to be taken. The students on whom the intervention was applied were not secondary school students. Thus comments upon this second frame of reference are limited.

It is required here that some assessment be made as to the probable contribution of the above-mentioned reasons to the change in the students' perceptions of science. There are three major probabilities with regard to the nature of science causing these female students disaffection with science. They are that:

1) The science is impossible to understand.

2) The science is very difficult to understand (some thought is required).

3) And the science is difficult to understand (a need to like science is required).

For each of these, there is some support held within this thesis. For the first there are comments made by the students in the first interview, the change in the students' perceptions as a result of the intervention, and finally the way that their perceptions changed (no students were found to like science and not understand it). For the second, the students' circumstances have changed. The students are now more mature and able to cope with the very difficult to understand science that they are now experiencing for the second time. Thus, students are able to think more about science and so understand it. Further the whole environment, within which the students are learning, is more conducive to learning science and the students now like science more. Finally, for the third there is again the fact that the science-learning environment is conducive to learning science, which makes science more likeable. On top of this is the possibility that the teachers are more proficient than those experienced by students at school and these teachers are able to make science lessons more likeable. To a greater or lesser extent, improving the nature of science would help these situations.

5.3.1 Science is impossible

It follows logically that if what occurs in the science classroom does not allow students to learn science (science is impossible) then students will not be gaining from a major part of their education. Thus if there is a problem with this aspect of science, then it is of importance. Further, if what students are learning is not correct, then even with the best teachers, all the students can expect to achieve is to effectively learn incorrect science. Once what they are

learning is correct then at that stage it is important to consider how to get this across to the student (i.e. teaching).

5.3.2 Science is very difficult

The science experienced in education only just allows students to learn it. To learn it there is a requirement to think extensively and in a manner that is appropriate to science. This ability may to some extent be gained through maturity or through the student experiencing the science more than once. In addition, to improve the students learning it is also beneficial to consider the environment in which the students are learning science. With this improvement, the student will like science and want to learn it. The teacher is required to allow the students to think and to try to develop this thinking. Further, the teacher also has to think about ways in which science lessons may be made more likeable.

5.3.3 Science is difficult

The science as is experienced by students in education allows students to learn it. However, to do this there is a requirement that the science lessons are made more likeable for the students. This likeability of science is improvable by considering the conditions in which the science takes place. Thus, for example the science needs to take place in an environment where peer pressure and teacher expectations promote learning rather than demote it. Further, the role of the teacher is important in creating science lessons that are likeable for the students.

5.4 Some personal reflections

To lay the blame solely at the feet of students, saying that they simply are not able to think in a manner appropriate to science may appear too judgemental. The ideas in science are not easy to understand, but if the ideas are not being presented to the students and they are not being given a chance to think about these ideas, it does not seem to be fair to judge students thus.

Finally, with regard the conditions of students learning and these resulting in students disliking science: the results from the intervention suggest that trying to make science more likeable to students will not necessarily make it more understandable for them. If there are problems with what is being learnt and how it is being learnt, this needs to be looked at first. It may, after all, be these things that students dislike so much about science.

With regard to science education, this research offers hope. The nature of science education as experienced by secondary school students (i.e. what science they learn, and how it is learnt) is perhaps worth investigating further. Once additional research in this area has been undertaken, perhaps students need not be so disaffected by science, having spent so much time in science classrooms, and having understood so little of that extensive amount of 'science' that has been presented to them. Thus, they may feel that they have gained something valuable from their science in school. Moreover, they may put to use or develop that which they have learnt after completing their education.

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7 Appendices

7.1 Appendix 1 -materials used in assessments

7.1.1 Appendix 1.1- Questions asked

7.1.1.1 Pre-intervention interview schedule

7.1.1.1.1 Questions to be asked during interviews

So to explain how we are going to do this interview. I want to know what you think about school and science. I have a sheet of questions to ask you. Some of the questions may include other information to help you answer the questions. There are three sections to the interview. I will record the interview so as to speed up the interview and as a memory aid. This interview is for research and as such is confidential. Is that OK with you?

INTRODUCTION- WHAT DO YOU THINK OF SCHOOL?

During this section I want to know what you think about school and in particular the subjects and peo

After the initial questionnaire

1. *I see that you chose to do s1, s2, s3 at A level. Why did you choose these subjects?*
2. *Did you have any difficulties choosing?*
3. What about the teachers of these subjects?
4. What about the school how did that help?
5. What did your friends take?
6. What about science? (if not mentioned above)
7. *Were there any other subjects that you would have liked to have taken?*
8. *What subjects were you definitely not going to take?*
9. Why were you not going to take these subjects?
10. How did your parents help you decide what to take? (Family can be used for the more mature student)
11. *What about your career?*
12. *Looking back on the choices that you made with the benefit of hindsight would you change your choices?*
13. Why or why not?
14. Who or what do you think gave you the most help in deciding which subject to take?
15. *What about GCSEs? How was what you took chosen?*
16. Were there any changes that you would make as to how that was done?
17. Were there any subjects that you perhaps would not have taken?
18. How do you think this affected the way that the lessons went in the classrooms?
19. *What sort of pressures were you under when you took these examinations?*
20. How did you overcome these pressures?

MAIN SECTION- WHAT DO YOU THINK OF SCIENCE?

During this section I want to examine the topic of science and the impression that it created in school

1. Changing the topic slightly now. *What import things happen outside school?*
2. *How do you find out about other things that go on in the world?*
3. What things are going in on now in the outside world?
4. (How are science and the scientist portrayed by the media?)
5. *Do you think that these things have any bearing on what happens in school?*
6. How or how not?
7. Would you change the way the outside world relates to school?
8. I have three newspaper articles here. I'd like to have a look at them one at a time and would like you to comment on them.

9. *Which topic do you think is most important? Aids, food poisoning, or the banning of handguns.*
10. Why do you think that the newspaper has chosen to write about these topics?
11. Why do you think that people read these papers?
12. When did you start to take more interest in the news and newspapers?
13. Why do you think this happened?
14. *Looking at the aids, food poisoning, handgun article when do you think that this becomes important to children today?*
15. How should they find out about aids, food hygiene, or handguns?(read article)
16. How do you think the aids, food poisoning, handgun problem could be solved?
17. How do you come to those conclusions?
18. (Additional questions for other topics)
19. *How was science taught when you were at school?*
20. Do you think that it was taught well? Why or why not?
21. *One method of teaching science is to do practicals. How were practicals done at your school?*
22. I've got three practicals that I would like you to have a look at. What do you think of the equipment used in p1, p2, p3 practical?
23. (what about the science subject)
24. *With p1 practical what do you think that you would do with the equipment?*
25. *If you were given this sheet r1 to go with the equipment. What do you think would be occurring in the classroom?*
26. Would you enjoy this experiment? Why or why not?
27. *If you were given this sheet in1. What do you think would be going on in the classroom?*
28. Would you enjoy this one? Why or why not?
29. What do you think are the differences between in1 and p1?
30. How would the teacher/pupils behave in each?
31. Repeat with other practicals.p2 and p3.
32. (Additional questions to go with practicals p2 and p3)
33. (What do you think of the layout?)
34. (What about the tables?)
35. (What about the picture?)
36. *How would these types of practical relate to the media problems? Or how would they help you solve the earlier media problems?*

SUMMARY- WHAT HAVE WE FOUND OUT?

This section will be the summary and I propose to clarify and expand upon the opinions that have been presented before.

1. *(What is school?)*
2. *(What is science?)*
3. *If you were going to improve the image of a subject how do you think that this could be done? (Ask about science if this topic does not come up)*
4. *In a classroom, where pupils are advancing what should be happening?*
5. *If a school topic seems very difficult what should be done?(if the interviewee mentions the teacher or pupils previously (50) then this can be added in the form.....done by the teacher/pupil as could be for questions 52 and 53.*
6. *If a topic seems very boring what should be done?*
7. *If a school topic seems irrelevant then what should be done?*
8. *How do you think that school should relate to what is required of people after they leave school?*
9. *(How do you think that the confidence of the pupil could be increased?)*

(In this last section the questions make reference to what has gone on before in the interview, however, the may have to be changed slightly if they are inappropriate)

Those questions in italics are the important questions, which should appear in all interviews those non-italic questions are supplementary questions.

7.1.1.2 The post-intervention interview schedule

Following the talks with my supervisors the following interview was suggested. The aim of the discussion was to modify the interview in such a way to make it more effective at obtaining information on the topic in hand. This would also have to relate to the past interviews, the literature and the examinations in a balanced manner.

7.1.1.2.1 Introduction

The interview is looking at your feelings towards science. I want to find out if they have remained the same or changed since before. Following this we will try to find out why it has changed or remained the same.

I will record the interview, for convenience and to make things quicker. Is this OK?

7.1.1.2.2 The Questions

I. How do you feel about science now?
   - A. Is this different from/the same as before?
   - B. How is it different/ the same?

II. Do you now think you could do/could not do science? (Even if it took a long time)
   - A. Is it a 'possible'/ 'impossible' subject?

III. Is there one bit of science that you are particularly happy/sad about?
   - A. Why do you feel happy/sad about it? (What made the difference? If applicable)
     1. Tell me about your differences-
     2. Which bits of this were problems? (When trying to understand this idea?)
     3. Were they missing before?

IV. I have two diagrams of objects/pieces of equipment that might be used to illustrate scientific ideas (topics of burning candles and gravity). I will show them to you one at a time.
   - A. Do you think that you feel positive or negative about this?
     1. Do you have a positive/negative attitude towards this idea?
   - B. Why do you think that you feel positive/negative about this?
     1. Why do you have a positive/negative attitude?
   - C. Which parts were problems? (When trying to understand this idea)
     1. What were the difficulties?
   - D. Were there any missing parts? (That helped you understand it?)
     1. Why did you have a problem with these parts?

V. Why didn't you understand these ideas before, do you think?

VI. Would you want to do more science now, if you could?

VII. Would you agree or disagree with the statement that 'your attitude towards science has changed since the beginning of the course'.

VIII. Would you like to make any other comments?

Notes questions 3.1.1, 3.1.2 and 3.1.3 are included if the topic mentioned here is different from the two that come afterwards. If it isn't then there they are omitted, as they will be asked later with the cards/equipment. Question 4 is based upon questions that deal with the topics on the cards. With the first card questions 4.1, 4.2 are asked and with the second card questions 4.1.1 and 4.2.1 are asked.

7.1.1.2.3 Brief explanation of questions

The interview relates to other evidence (first interviews, research literature, and students' abilities) withi

- The word 'attitude' is used within the interview schedule and relates back to the first interview in which their attitudes towards science were examined.
- The cards/ equipment, used to illustrate selected scientific ideas, relate to concepts that have been studied in literature before.
- One of the attitudes examined in the interview is that ' I could not do science'. This attitude is one that relates to the pupils ideas with regard to their own abilities in the subject of science.

7.1.2 Appendix 1.2- Materials used in interviews

7.1.2.1 Worksheets

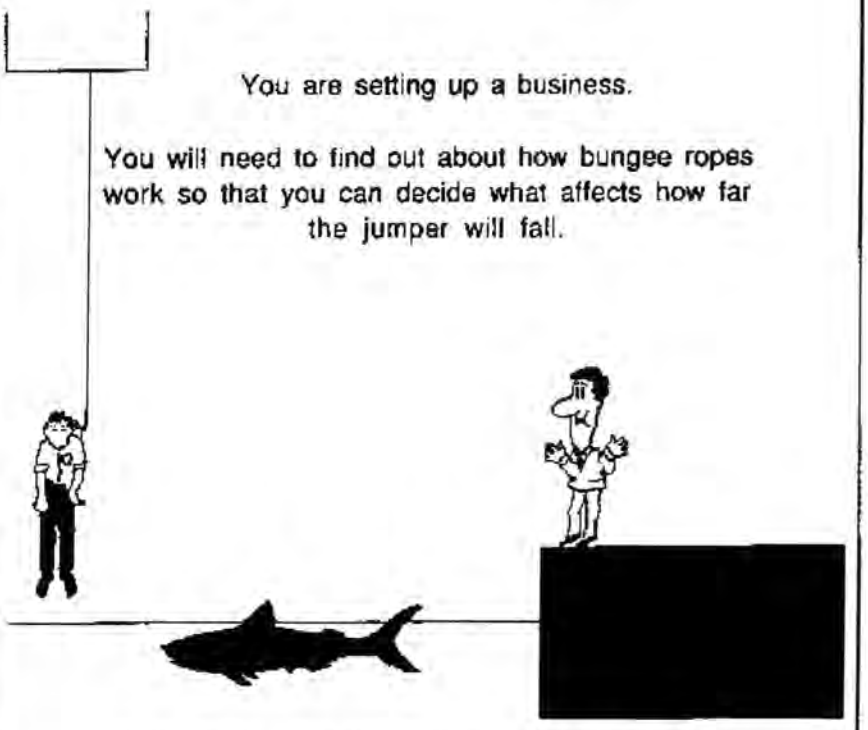
31.2

Bungee jumping

Go back

Index

Bungee jumping



You are setting up a business.

You will need to find out about how bungee ropes work so that you can decide what affects how far the jumper will fall.

Remember - the safety of your customers is a significant feature of this bungee jump. Dead jumpers are not good for trade.

Create a handbook for your assistant - who needs the information in simple terms.

Mouldy bread investigation

You are a planning to open up a shop in which to sell bread and cakes. To try to keep the bread as fresh as possible and to pass the health and safety test which is applied to all shops then you have to know how to stop your bread going mouldy.

Ergotism- A disease caused by bad bread

The last outbreak occurred in Pont-St. Esprit in the Rhone Valley in 1951, and the tragedy is fully documented in John Fuller's book, *The Day of St. Anthony's Fire*. Rye flour, infected by the fungus *claviceps purpurea* which contains the poison alkaloid ergotoxine, was made into bread and sold to the villagers, with the result that "hundreds of respectable townspeople went totally mad on a single night. Many of the most highly regarded citizens leaped from windows or jumped into the Rhone, screaming that their heads were made of copper, their bodies wrapped in snakes, their limbs swollen to gigantic size or shrunk to tiny appendages. Others ran through the streets, claiming to be chased by 'bandits with donkey ears,' by tigers, lions, and other terrifying apparitions. Animals went berserk. Dogs ripped bark from trees until their teeth fell out. Cats dragged themselves along the floor in grotesque contortions. Ducks strutted like penguins. Villagers and animals died right and left."

If your shop is germ free and your bread fresh then you will get lots of customers
People falling ill from germs in your bread is bad business!

Betty's Tea-rooms,
16, Parliament Street,
Harrogate,
North Yorkshire,
25th October 1994

Dear Sir/Madam,

I am writing with regard to a recent problem that we are experiencing in our tea-rooms. During any given day we serve hundreds of cups of tea and coffee to our customers. After collecting in all the cups and saucers, we then are required to wash them for the next day. So that the next wet customers can once more drink from the same cups.

Unfortunately, our washer uppers have reported to us that significant amounts of sugar have been found in the bottom of these cups. They therefore take a long time to wash and also the pipes get blocked up. This seems to occur most often in winter.

I would be most grateful, if you could investigate this situation for me and propose any situation that you may think appropriate.

Yours faithfully,

Ivar Problem

Managing Director

Things to think about:

What factors effect the dissolving of sugar?
How can we test these factors?
What do you expect the results to be?

1 Dissolving substances at different temperatures

1.1 Aim of Experiment:

To find out if the amount of sugar dissolved goes up as the temperature goes up.

1.2 Apparatus:

Bunsen Burner, tripod, gauze, beaker, thermometer, water, sugar, stop clock, spatula

1.3 Method:

1. Add sugar until no more will dissolve
2. Repeat at other temperatures
3. Draw results table
4. Measure temperature and fill in results table.
5. Set up the apparatus with gauze on the tripod and beaker of water on top of this.

Fill in results table

Place method in the correct order as it has been muddled up.

Draw a diagram of how you think the apparatus was set up.

1.4 Results

time in seconds	temperature in °C	amount of sugar dissolved in spatulas	amount of water in cm^3

Questions:

1 What happens as the temperature of the water increases?

2) What happens to the particles in the water? Do they move faster or slower?

3) Does this mean that more sugar will be dissolved or less?

4) Plot a graph of the results- either a line graph or a bar graph.

5) Describe the graph that you have drawn.

6) After the experiment the sugar solution was heated until all the water evaporated. What was left in the bowl?

2 Experiment on mouldy bread

2.1 Aim of experiment:

To find out if temperature affects the speed at which mould is produced on bread

2.2 Apparatus required:

piece of bread, knife, magna-spec, three petri dishes, sealing tape, thermometer

2.3 Method:

1. Acquire apparatus to begin practical
2. Cut piece of bread into small 1cm slices using the knife provided
3. Place piece of bread in petri dish and seal it using the tape
4. Place petri dish in area of classroom
5. Using thermometer measure the temperature of the area where the petri dish is to be placed
6. Leave for 1 week
7. Repeat with two other petri dishes in different areas of the classroom
8. Using magna-spec measure the amount of mould on the bread
9. Fill in table

2.4 Results table:

size of bread	area petri dish placed	temperature	amount of mould after 1 week

2.5 Discussion:

Answer the following questions:

1. Which piece of bread had the most mould on it?
2. What was the temperature of this piece of bread?
3. How does temperature affect how mould grows?
4. Give a scientific explanation of this.

3 Measuring and drawing line Graphs

3.1 Aim:

To find out what happens when weights are added to a rubber band and to plot a graph

3.2 Apparatus required:

Rubber band, small hook, stand, clamp and boss, G-clamp, ruler and safety goggles

3.3 Method:

1. Obtain apparatus above and set up as described by your teacher.
2. Measure length of rubber band, measure thickness of rubber band
3. Add weight (10g) to the hook attached to the rubber band
4. Record results in a table
5. Repeat steps 2,3,4

Plot a line graph of the results using the horizontal axis to record the weight added and the rubber band and the vertical axis to record the stretch of the rubber band.

3.4 Results table:

thickness / cm	weights added /10g	beginning length /cm	end length /cm	extension /cm

3.5 Discussion:

What type of graph is produced?
Explain the line graph you have drawn.
What happens close to the origin and why?
What happens when many weights are added to the rubber band and why?

7.1.2.2 Newspaper articles (from the world wide web)

Scientists warn of 'super' Aids bug
By Robert Uhlig, Technology Correspondent
External Links
AVERT: Aids and Education Research Trust
New Scientist

Medical Research Council

A SUPER-STRAIN of the Aids virus, said to be of particular danger to heterosexuals, has spread from Thailand and America to Britain, a report says today.
The subtype E variant of HIV is endemic in Asia, where most HIV-positive people are heterosexual, leading scientists to suspect that it may be spread preferentially by heterosexual contact.
In Britain, most cases of HIV to date have been caused by subtype B, which has predominantly infected homosexual men. The report in New Scientist warns that researchers at the Public Health
Laboratory Service are unable to assess the full extent of its spread because of a lack of funding.
Since John Clewely, head of molecular biology at the laboratory, in north London, announced Britain's first case of subtype E on May 25, scientists there have identified a further 72 cases.
The new cases - 60 men and 12 women - are thought to have caught subtype E from sexual contact in Thailand, or from partners who had visited Thailand.
Evidence supporting heterosexual spread preference includes research by Max Essex, of the Harvard School of Public Health. He has found that the strain is more adept at infecting cells lining the vagina and tip of the penis than other subtypes.
About 19 per cent of the 25,000-plus HIV cases in Britain are thought to have been contracted through heterosexual contact.
Scientists say they need to carry out large subtype tests on a random sample of HIV positive people to assess the true spread of subtype E, rather than the present two random sample tests a month.
Dr Clewly is asking the Department of Health and the Medical Research Council for funds to expand the testing programme.
2 July 1996: Aids campaigners deny exaggerating HIV threat

Food poisoning claims sixth life
By Auslan Cramb, Scotland Correspondent
External Links
The E coli
Index
THE food poisoning epidemic in central Scotland claimed a sixth life yesterday as it was alleged that the butcher blamed for the incident sold cooked meat for a private function the day after he was told about the outbreak.
Lanarkshire Health Board said John Barr, whose Wishaw shop has been linked to the E coli epidemic, supplied cold turkey, ham and beef on Nov 23. The meat was eaten in sandwiches at an 18th birthday party attended by 106 people in a public house at Coltness, Wishaw.

"It has come to our attention that a range of cooked meats (turkey, boiled ham and roast beef) was supplied by John M Barr and Son, Wishaw, on Saturday, Nov 23, for a private function, an 18th birthday party at the Cascade pub, Wishaw, that evening," a statement from the health board said.

Police are investigating the incident and the health board said it had spoken to 98 of the partygoers, 22 of whom had symptoms of E coli 0157 poisoning. One youth is being treated in hospital. Last night environmental health officials had made "some form of contact" with another five people at the party and were trying "urgently" to contact one other person.

The sixth person to die was a 72-year-old woman who was being treated in Monklands Hospital, Airdrie. She had been in hospital for eight days.

Another 25 suspected cases were announced yesterday, bringing the number affected to 307, with 168 confirmed cases and 51 receiving hospital treatment.

Seven children who contracted E coli virus were granted legal aid yesterday to sue two Whitehall departments, the Ministry of Agriculture and the Department of Health, for negligence. Action could also be taken against three private companies, including McDonald's Restaurants and McKey Foods, of Milton Keynes, which supplies the hamburger chain.

1 December 1996: Scared shoppers avoid meat shelves

Next Story: Pc 'shot man who posed no threat'

Major set to back ban on handguns

By George Jones, Political Editor

JOHN MAJOR is ready to overrule Tory MPs and legislate for tougher laws on gun ownership.

A ban on keeping handguns at home is not ruled out by ministers, if it is recommended by the Cullen inquiry into the Dunblane massacre. Ministers made clear last night that they would be guided by the outcome of Lord Cullen's inquiry rather than by the Commons home affairs committee report.

The six Conservative MPs on the committee voted against outlawing the private ownership of guns, as disclosed by The Daily Telegraph on Tuesday. The Cullen report is expected to be published next month. Yesterday Downing Street promised a "quick and positive" response to it.

Mr Major has said the Government is keeping room in the autumn's legislative programme for a Bill to implement its recommendations. Around 57,000 people hold certificates for handguns and 45,000 have permission to own more than one.

Michael Forsyth, the Scottish Secretary, whose Stirling constituency includes Dunblane, favours a ban.

Yesterday, he criticised the select committee for coming to a conclusion before Lord Cullen's report.

"The select committee would have been better to have drawn their own conclusions in the light of the Cullen report. That is what the Government intends to do," said Mr Forsyth.

Mr Major also believes action is needed to prevent a repetition of the Dunblane and Hungerford massacres, but wants to see what Lord Cullen recommends. Ministers are also attempting to defuse a row over reports that Tories on the committee used their majority to out-vote the five Labour MPs, who supported calls for private ownership of handguns to be made illegal.

The Government sought to distance itself from its MPs after parents of children killed and injured at Dunblane reacted angrily to the disclosure that the committee had split on party lines. Anne Pearston, one of the organisers of the Snowdrop petition, which has

gathered 750,000 signatures in favour of stricter gun laws, said she hoped the Cullen report would recommend a ban. "We have had two massacres by people holding handguns legally and it is unacceptable for people to live with that risk," she said.

The six Tories - Sir Ivan Lawrence (Burton), the committee chairman, David Ashby (Leics NW), John Greenway (Ryedale), Warren Hawksley (Halesowen and Stourbridge), Dame Jill Knight (Edgbaston) and Walter Sweeney (Vale of Glamorgan) - were also criticised by a fellow Conservative, David Mellor, a former Home Office minister.

He said on BBC Radio 4: "I think they are mistaken, and there is a serious danger of the Conservative Party at all levels losing the plot on this very serious matter. There is no doubt the public wants a ban on handguns."

John Prescott, Labour's deputy leader, said he was "absolutely staggered" that MPs should have voted against banning handguns at home. "The public want it. It's common sense. The evidence is overwhelming." The Labour MPs on the committee are expected to produce a minority report calling for a ban on handguns when the main report is published on August 13.

Mr Greenway said of his colleagues: "We have concluded that a ban on handguns would be impractical." They understood the demands for a ban after Dunblane, but had looked at the issue dispassionately and decided that it would not prevent such incidents. "It is the way that firearms certificates are issued where the law needs to be strengthened," Mr Greenway said on BBC Radio.

Next Story: Strikes planned by rail unions

7.1.2.3 School science equipment used

7.1.2.3.1 First interview

Bunsen burner, tripod, gauze, beaker, thermometer, water, sugar, stop clock and spatula

piece of bread, knife, magna-spec, petri dishes, sealing tape, and thermometer

rubber band , small hook, stand , clamp and boss, G-clamp, ruler, weights, and safety goggles

7.1.2.3.2 Second interview

Wax candle, matches

Rubber band and a set of weights

7.2 Appendix 2- some examples of the results obtained

7.2.1 *Appendix 2.1- the education questionnaire*

7.2.1.1 *Examinations taken (part 1)*

code	add ma	art	biolog y	bus st	che m	cdt	ch dev	cla civ	comp u	dram a	Eng lan	Eng lit	exp ar	geo	fo sci	Frenc h	Germa n	gen st	Histor y	huma n
bb		a,**C**[1]			b						b	b,**D**					d		c,**C**	
xx		a,**C**	c		c	b					a	a,**B**		d		b,**E**				
aa						a				c	b	c,A	a			b		b,C	b,B	b
hh			b		b		b		b,C		d	c,C				b			c,D	
oo	c		b		b						b	b,A		b,B		a				
gg		b									a	c				b,B	a,B		b,B	
tt		1			1	2					1	3		3						
ll											a*	a,B				a,C		A	a,C	
uu			b		b						c	b,B		b		a,C				
cc	b	a				a			A		b,B	b								
kk									e		a,C	b		a,A		b			b,D	
mm				a					B		a*,A	a*				b			a	
ww			a,B							b	b,B	b,B		a,A	b	c,C			C	
jj			b		b	B					a	a		a,E		a				
pp								A			a	b		a,B		c			a,C	
ff			D		C					C	a	a		b	a	b			b	
rr					b		a				b	a,C		b,D		a				
dd		c								b	b	b,B		b			a		a,B	
vv					c			C			b	b,C		c,C		b	b		b	
ee		c	c				b				c	c		c						
ss		a,A				c					a*,A	a*		a*, B			b			a*

[1] Small letters represent grades obtained in GCSEs. Capital letters represent those obtain in A-levels

7.2.1.2 Examinations taken (part 2)

code	Latin	maths	music	phy ed	physics	Politics	psych	rel ed	sci gen	Span	socio
bb		c	d		b						
xx		c			c						
aa		b							cc	a,D	b
hh		b			b						
oo	c	a,C			b						
gg		a,C	a						bb		
tt		3, ACCESS[2]							ACCESS		
ll		b	a						bb		
uu		b	b		b			b,D			
cc		a	b						b		
kk		c							b		
mm		b				B		a*	bb		
ww		c		B							
jj		c	a,A							b	
pp		b							bb	b	
ff		c						a	b		
rr		b					B		bb		
dd		c							a*		B
vv		b			c						
ee		c			c			b			BTEC[3]
ss		b							aa		

[2] Student undertook ACCESS course

[3] Student undertook B.Tech award

7.2.1.3 Abbreviations used for subjects studied

Additional Maths	add ma
Business Studies	bus st
chemistry	chem
Child Development	ch dev
Classic Civilisation	cla civ
Computing	compu
English language	Eng lan
English Literature	Eng lit
Expressive Arts	exp ar
Geography	geo
Food science	fo sci
General Studies	gen st
Humanities	human
mathematics	maths
physical education	phy ed
Psychology	psych
religious Education	rel ed
science (general)	sci gen
Spanish	Span
Sociology	socio

7.2.2 Appendix 2.2- example one - code kk- first assessment transcription

7.2.2.1 Interview with KK

I: So to explain how we are going to do this interview. I want to know what you think about school and science. I have a sheet of questions to ask you. Some of the questions may include other information to help you answer the questions. There are three sections to the interview. I will record the interview so as to speed up the interview and as a memory aid. This interview is for research and as such is confidential. Is that OK with you?

INTRODUCTION- WHAT DO YOU THINK OF SCHOOL?

I: During this section I want to know what you think about school and in particular the subjects and people who were there.
I: I see that you chose to do History, English literature and English language for your A levels. Why did you choose these subjects?
KK: Well I've always enjoyed Geography and the subjects it was the ones that I did best at GCSE.
I: Did you have any difficulties choosing the subjects?
KK: I new that it was definitely geography and then it was going to be like it was between history , English and environmental science which of the two I took. So I was all right when I got my results through I new straight away what I was going to do
I: oh great..
I; What about the teachers of these subjects? What were they like?
KK: It was one of the major decisions, like a major part of which A levels I decided to do. So they were really good teachers. The best department in the school really.
I: What made them good teachers for you?
KK: well my geography teacher it was the way that we had a few jokes and that and then we got something back into work. It was just the way that we like respected him and like new when to switch and things like that. With my English teacher she always made it interesting I liked the choice of book. In History I've always really been interested in History
I: What about the school what other things apart from the teachers helped you decide?
KK: well I've always enjoyed school so I knew that I'd stay on at sixth form at school rather than go onto like college or somewhere...I've been with most of my friends since infants school and then made a lot more when I went to Brighten Beds and just went nearest to home and things like that. It wasn't too far only a bus journey things like that..
I: What about your friends? What did your friends take?
KK: A lot of my friends did Geography and history there wasn't many of my friends who actually did English.. So I've made new friends doing that as well

I: What about science? You didn't take any science.
KK: no I never even thought that I'd pass GCSE then.. So I was at one point contemplating doing biology and I was told that it had a lot of chemistry in it and that put us straight off..
I: Were there any other subjects that you would have liked to have taken?
KK: I don't know I was fine with my choice because we had a lot of reading and things involved and I didn't think I could do anymore. I also did one year AS level in general studies in the lower sixth which was interesting. But I was fine with the ones that I did I don't think that I could have coped with any more..
I: What subjects were you definitely not going to take?
KK: maths physics, chemistry and French I didn't like French very much
I: Why didn't you like maths?
KK: I'd always managed all right with it until I came to do my GCSEs . I did get entered for the higher paper which there was only about half a dozen of us in the whole year got entered for the whole paper . So but I always I don't know I'd get it but it just took a while but I don't know but I'm all right with maths basic maths just GCSEs started going a bit over my head. I can just imagine what A-level would be like.
I: What was the other one chemistry?
KK: we did just science all together so it was obvious that it was split up into chemistry, biology and physics but it was just like called science... I don't know I was never fussed with it really. It didn't appeal to us. It didn't interest us. I didn't enjoy it at all
I: And physics?
KK: oh I could never do physics. No I didn't have a very nice teacher either
I: How did your parents help you decide what to take? Did you talk to them about it or not?
KK: I probably did at the time I can't remember you doing it but ... I don't know me mam I was like.. She knew what I liked so I said mam I want to wait until my results come out because we like had sixth form induction before the summer holidays that's after my GCSEs you could go then and like sit in lessons of sixth form to see what it was about so I had a few that I knew that I could like pick. I could pick three fun type things so... They gave me support all the way though secondary school me mam and dad.
I: What about your career? Did that come into it?
KK: I always knew that I wanted to become a teacher. I had to because that is what I wanted to do, but at A level I didn't think much. I wanted to find out if you had to have a science at 'A' level as I wanted to .. If there was any specific requirements to become a teacher at A level and if there had been then I would have maybe rethought my choices, but asking about.. There didn't seem to be that much so I went for what I liked.
I: Looking back on the choices that you made with the benefit of hindsight would you change your choices? Would you have done anything different?
KK: I wouldn't have done History well I don't know what I would have done. I was always good at History until A level and it was just getting used to doing essay like questions and I just couldn't grasp that idea. So I don't like when I can't do things.
I: Who or what do you think gave you the most help in deciding which subject to take?

KK: ... I don't know I think that it has got to be looking back a lot of it was based on GCSE and how I enjoyed there and how I enjoyed the teachers the amount of work and things like that. Like a lot of my friends chose work that didn't have any course work that well it happened that two of mine did, but I'd prefer doing course work. I'd rather know that I've done all right when I go into an exam and things like that so... That helps I did talk to friends and teachers about what it would be like so.... There wasn't anything major that stuck out

I: What about GCSEs? How was what you took chosen?

KK: you had to there was like a list of like there was a, b, c, d and you had to choose an option out of everything. You'd do English, maths and science, well I liked geography, well I never liked geography at Brecken Wedborough where I went until I was fourteen, but I was talking to some of my friends who were a year older than me and they said do geography because the teachers are really good so I knew that I definitely wanted to do that. I'd always like History.. Oh I did French because I never did a language before and then I did computer studies...it is not hard to arrive all that down it is down there.

I: oh you put it down there

KK: I got an A unbelievably. So there wasn't much choice History and French were in most columns so there was only really the last one where it was a choice of whether I went into computers or cookery or something like that. So there wasn't much choice.

I: Do you think that that is a good system

KK: yes cause I was .. I think at GCSE you've got to have a broad range and with the likes of geography and history and French being like there was a chance that you could do it a lot of the times I think that you need subjects like that but I didn't think much about it at the time really. I was just fourteen and I'd started a new school. I can't remember thinking about it.

I: Was there anything that springs to mind that you would have changed if you had a choice?

KK: well I liked all of what I did. GCSE subjects.

I: How do you think this affected the way that the lessons went in the classrooms?

KK: .. Well in the subjects that were chosen to do the lids had the enthusiasm, but maths and science I was a bit ohh and drag a long type thing.. So because I had the choice and I'd chosen them and it wasn't the case that I was being forced to do these subjects. Well I've got to get on with it type thing so that is how things went I think.

I: What sort of pressures were you under when you took these examinations? Thinking about your GCSEs and A level.

KK: personally I've always been wanting to do the best that I can do things and I can do me best. Me mam and dad have like helped me and realise that I can do things and do me best and liked it when me mam and dad said have you done your homework type of thing which I was well shut up type of thing but now I'm pleased that they did make sure that I had all my work done because I'm not sure that I would have been all that conscientious. My GCSEs would have been the first major exams that I had done they were terrifying and I just worked just non-stop. It just overtook my life for about three month. With A Level to come here there was a lot of pressure on us both times.

I: What or whom made it terrifying for you?
KK: not. I.. Personally I wanted to do well and I would have been very disappointed if I hadn't like if I hadn't passed all me GCSEs or anything like that because my teachers said I had the ability oh they said you will get this you will get that and all of that type of thing In a way I wanted to do well for my mam and dad for my teachers and things like that but more for myself
I: How did you overcome these pressures that you were under?
KK: I worked ...looking back on myself now I just took GCSEs and I worked for three months. At times I probably did too much because I started to panic. I was all right when I was working otherwise being terrified of exams and things so..
I: OK that is the bit about school over with

MAIN SECTION- WHAT DO YOU THINK OF SCIENCE?

I: During this section I want to examine the topic of science and the impression that it created in school upon you. I would also like to look at the media and compare the impression that is portrayed by the media to that in school

I: . *What import things happen outside school?*
KK: For me what did I do outside school?.....
I: well sure tell me whatever you like....
KK: I can't think .....to do with science?
I: anything?
KK: during my secondary school I always had involvement with children.. So I helped at any local youth club I worked behind the tuck shop , I've helped at Brownies for the last five years , things like that.. I've always done loads of baby sitting and at school I was always doing homework . Sometimes I wish that I hadn't been .. But more recently that has gone a bit down the drain I was out a lot more ...
I: How do you find out about other things that go on in the world?
KK: I try and watch the news once a day. I hate it when I haven't seen the news for a few days . I think what is going on in the world type of thing. We have never really been ones in our house to get a paper everyday, but we do get one on a weekend so I've always read them things
I: What things are going in on now in the outside world, that you think are important?
KK: well doing an education degree I'm always interested in the news and what things are going on and I do buy the Times Ed once a week. That's what I read. I don't know what interests us . I'm into like things.. I don't know things that are like happening to people... If there is something happening on the news like ... World-wide human issues type of thing . They interest us more. I think....
I: Do you think that these things have any bearing on what happens in school?
KK: I think so to differing extents . I don't know especially if you are teaching them top juniors or something . I think children are more aware of what is actually going on. You've got to be prepared yourself so that you can answer things like that but ... Things like

growing concern about the environment over the past couple of decades and now you've got to teach that in schools and things like that . Learning about the environment comes... Well when I've been helping in schools that has come up quite a bit learning about the environment and things like that .. So I think they do if children ask questions and things like that you follow them up and maybe do an activity or something like that.

I: Would you change the way the outside world relates to school? Would you bring any more things in?

KK: I think that the subject choice is all right especially for just... It is better in primary school but the maybe in secondary schools there should be maybe .. I don't know .. I mean I'd always wanted to do drama GCSE things like that. That wasn't available in our school. I don't know that maybe .. And a lot of my friends went to college rather than sixth form, because there was like psychology, sociology you could do. So when they are at that stage but I think that when they are with National Curriculum subjects that maybe there is not enough there

I: I have three newspaper articles here. I'd like to have a look at. I don't know if you've read or listened to any of this there is one about Food poisoning, and there is one about Handguns and there is one about AIDS. So starting with Food poisoning. What do you know about the topic of food poisoning.

KK: I don't know we just saw that at college last week

I: OK of these three topic which do you think is the most important?

KK: I was watching GM tv this morning and I was getting ready and there was a program on whether children should learn to use guns. I think that AIDS like people having AIDS is growing rapidly I think that that has got to be an issue as well. Children should... Well maybe not so much lower primary but perhaps upper primary I think that that should be made... ,but definitely handguns I don't think kids should be taught how to use a gun .

I: And food poisoning. It is quite a high issue?

KK: I don't know what's going on about that .....I can't remember.

I: you mentioned television, are there any other ways that you find out about them?

KK: all sorts of forms, general reading, the newspaper the radio things like that and really you meet people in the streets wanting you to sign petitions, for against the use of handguns things like that

I: Why do you think that people read these papers?

KK: depends a lot of them want to read the sun and the mirror for all the scandal, people who read the Sunday People that is what they read it for ..... I don't know if people choose to read a newspaper because of their political background towards them or just that they like to know what is going on. I don't know if there is something about the Royals people go out and buy. Most peoples want to know what is going on and these types of thing. To know what is going on around them

I: When do people start to take more interest in the news and newspapers?

KK: I think that it depends on the individual. I've always enjoyed reading as I've ..as I was younger if there was a newspaper in the house I'd always try to

pick it up and have a read of it. I mean sometimes I just do go out and buy myself a newspaper to see what is going on, but I don't know really maybe it is because my mam and dad. I mean I've always been encouraged to read, my sister has never read anything. I think that it depends on the individual, but I think I don't know if you could put an age on it, but senior school age I'm sure

I: You mentioned that you thought that Handguns was an important topic. How should they find out about handguns or not as the case maybe?

KK: well guns in general you had Dublane about this time last year children pick up on things like that... You know what I mean... Because something like that was talked about everywhere. With children they hear bits of conversation and they pick up on that but I don't know. They catch snippets in the news or see something in the newspaper... But it kind of has its stops and starts about it. Handguns in the papers and thing like that, but I think that more and more children don't play cowboys and Indians and things like that . I know that the kids that I baby-sit for the parents are kind of.. A lot of them are not keen on them having toyguns and that I've seen that like I don't know

I: OK I'd like you to have a quick read of this and tell me what you think about it.

KK: that is more of a labour , conservative like contradicting their ideas and that it is like name dropping and things like that and they are bringing in Dublane and Snowdrop petition and things like that ... I don't know it is kind of like they are trying to beat each other out in a way. John major has safe something so the con... So the labour have got to get back ... Argument

I: How do you think the handgun problem could be solved?

KK: I think that personally I think we need stricter gun laws, but when we've got laws for everything we still.... I don't think that it is going to be simple thing to solve because I mean goodness it has been around a long time , but I don't know I think , well Dublane was a once in a million occurrence but it happened and like now everything about guns was it Prince Charles who like , well was it one of his sons that he was letting him shoot , but now as soon as something happens with guns it is immediately brought to the media so . Like the Snowdrop petition that got all the signatures.. People are obviously wanting things to be done , but I don't know that by bringing in the laws that it is going to solve all the problems . I definitely think that they should have a try anyway. Especially on ownership in the home. I don't think that there is any need for it really

I: How would you decide what the laws were?

KK: well I think that I'd see what the public are after. I think that that is really important. Some people I don't know if it is getting more and more like America with its guns and that for personal protection and I think that it has come to the stage where you do need to protect yourself but I don't know if I think that they vote in they could stop gun ownership at all. Just have them in clubs then It is not going to be a case of like gangs shooting each other

kind of thing because if you... I mean they should but I don't know if laws actually work. I'm not sure on this one.

I: How was science taught when you were at school? Do you remember that far back?

KK: It was more a case of us sitting and watching and I didn't like that it was too it was too boring and all the GCSE science it was like physics it was like all these laws you had to learn . I just couldn't be bothered with all that. Biology I've always like biology.. I found it a bit too. I mean it was easy to learn. I t was difficult, but it wasn't. I think that it was more just a case of us sitting there watching that I didn't like there wasn't much that we could get involved in.

I: OK how do you think that you might improve that?

KK: I don't know just like they are doing matters and interaction courses do it the way that. The way that it has been explained at a much easier and going right back to the beginning and that. I just wish that the teachers at school had done that. They just said it and it had been basic. I don't know half the time we were just reading out of books and that. We were taught in such scientific terms that I just switched off after five minutes because now we are going back to basics I'm actually understanding things that I've done . Like science at school

I: One method of teaching science is to do practicals. How were practicals done at your school?

KK: Sometimes it was more a case of the teacher would stand at the front and things , but at GCSE we had to do , twenty five percent was based on the experiments that you did of the mark . Like when I came out of junior high school I wasn't much involved in it like math, but German GCSE there was bit more now thinking back.. I don't know if it was a case of you being in groups of two or three. I mean you were shown how to do it first and then you had to do it and you were told the results

I: I've got three practicals that I would like you to have a look at. We will start off with.. Which one shall we do first? How about this.... So say we come into the classroom and see this equipment, what would your reaction to it be?

KK: oh at first it would be oh we are not just going to be sitting there if it was out in the front type of thing, but that microscope looks a bit well not frightening but I'm always wary of things that I have never ...had proper use of type of thing . I don't know things look at bit. I don't know may be once I got into it I'd understand things but just looking at that straight away I think the equipment does look. I don't know a bit weird but I've done it ... It was I'm not used to seeing that type of thing. I am now but at first it was a case of oooh it is that type of thing.

I: do you know why?

KK: no it is just one of those things. I've never really been one for science really.

I: What sort of things do you think you'd be doing with this sort of equipment?

KK: I don't know it could be making slides of little things . I don't know what it is... Cells or something like that.....

I: OK the next lot of equipment . There is only three lots . OK so you have got these things what do you think ? What are your immediate impressions?

KK: I hate Bunsen burners... I'm a little bit better now but at first I could never light a Bunsen burner. I'd watch from here, but I'd have to find someone who could ...who I know isn't afraid of things like that, but just personally for me I don't like Bunsen burners, but apart from that now. I'd be all right as I know what it is like.. This stirring thing and that but at first I just hate Bunsen burners because I hate fire. I've always been scared of matches and things so doing things with Bunsen burners it was awful it was all right at a distance but if you had to do anything by yourself I would just panic... I'd have to get someone else to light it and things like that.... And sit next to them .....

I: Why do you think that is? Do you know?

KK: I burnt my finger on a match when I was little. All I was doing was letting the match burn too far down and I burnt my finger and since then I don't want anything to do with matches or flames or things like that...sigh

I: And finally we have this. So what do you think?

KK: that is all right ...well now it is because I know the sort of things .... I always knew what a clamp stand was..that doesn't bother us , but it was a case of oh god what am I going to get into doing some proper things today I suppose get involved

I: You said it wasn't always like that what sort of changed your mind do you think?

KK: I don't know I've always been scared of things, well not scared of things but wary of things I've never done before. I've always been a bit nervous. Especially with science as I've always found it difficult to understand, but I don't know as I've done more and more science. It has got easier and I quite enjoy it now because I'm doing this double module. I only chose it because I thought that I couldn't do science, but.....

I: What do you think has convinced you that you can do it now?

KK: parents evening it was that... Exams....I always did all right in biology but in physics and chemistry I was like just passing and then when I got my Bs in my GCSE I was just oh I can do science... But I didn't want to do it for A level. Like now things have been explained a lot more easier. I'm beginning to understand it and grasp concepts ... But I think that now I maybe can. I can give it a go Just a few years ago I'd have never gone near science .....

I: What do you think has changed.. What has made this change? It is a difficult question I know>

KK: I don't ...know... When I chose to come here I was going to take English as my main subject and I suddenly thought.. Science has never been my strong subject and I can get through it if I learn things parrot fashion but I've never understood them.. I just think that now science has become more and more important in primary school. I thought well everybody has to do one module in science and I thought maybe it is important if I look at science a bit further, because I didn't have to have any A levels in science to do it and with the title principals of science that didn't sound as daunting as physics, biology and chemistry which I've done before and I'd got a bit wary of and I knew I couldn't do it. But well now I have got a lot more confidence and I am

enjoying it a lot more because I'm beginning to understand things. It is the way that things are explained. Maybe it is because at last I'm a bit further to becoming a teacher and I'm putting all my enthusiasm into all my lectures and at school science was like you had to do it type of thing but now I've chosen to do it . I don't know whether that makes a difference. I'm not sure really
I: OK suppose the teacher came in and said well we are doing an experiment today and we are using this equipment and they give you this sort of sheet to do. What do you think?
KK: ...well I could do things like that I'd be all right when it is set out, but I'm still a bit wary of being told. Like in evidence it is a bit more working off your own back and getting your ideas together and I'm getting a lot more confident with that now but I'm, but this being set out and being told exactly what to do that is fine I can coup with that ... Just read it and put it in boxes I can do that no problem.. No that is fine that.
I: What would be happening in the school classroom?
KK: I don't know just getting in groups of two or three and just getting on with it and because you are doing it on a more individual basis you actually you can.. You are having to concentrate more like if it was a case of it's a school where the teacher is stood at the front and you watch what was happening you often didn't get a good enough view or it was easy for you to switch off. Now that we are doing things like lab files you know that you've got to stay awake and do the things yourself and I think that it is a lot more interesting the ways that things are done.
I: OK what do you think of the subject material?
KK: well doing something like mouldy bread everybody has seen mouldy bread you know what I mean... And you kind of know what to expect whereas the first time you burnt the sugar you didn't have a clue what was happening. I nearly died when it was a light. I was going ohhhh... I almost set the lab on fire. I don't know doing things with mouldy bread.... it sounds a bit of a weird experiment but.... Everybody has seen mouldy bread it doesn't bother us ... I mean I know what to expect...
I: What do you think you'd be doing in this particular one? How would you do it?
KK: I'd just follow the method real and make sure that I'd done everything right. If I was told to find out if temperature effects the way that bread moulds as it says then I think that would be a bit more daunting to do.....I probably could have come up with similar like things, but I don't know. Well when you have to think about it for yourself I haven't the confidence to think that I'm doing things right. Like on an individual basis
I: well instead of that sheet of paper perhaps the teacher might give you this one. What do you think of this one?
KK: see I wouldn't have liked that one as much because you have to ... Well I don't know whether it is a case of well I'm lazy I can't be bothered to think but it is a case of when you are just given that like not knowing anything about that one.... you have got to like read through what is happening and like think and here you have got an idea of yeah you are wanting to sell breads and

cakes, but I don't know whether I have got any confidence to think well if I did that then that would be fine. Well if I was working in a group and someone else said it and thought the same thing as I thought then that would be all right. I just don't know I haven't got the ... I'm still worried about that when I'm thinking about science because I haven't overcome the lack of confidence that I had in the past. It is getting there, but I definitely prefer that one.
I: What about the way that these two are set out?
KK:....well that one is easy you've just got to read and follow where as that one you've got to decide what you are going to do , what equipment you are going to use you've got to plan tables and how you are actually going to display your results and work out I mean to come to some sort of conclusion and if you were asked to write up about it. There is a discussion part there. ... You have actually got the questions, but if you were asked to write it up as a lab file you are going to have to think about the questions that you are going to have to answer.
I: so what do you think are the differences between the two of them?
KK: well you've got illustrations between the two of them, I don't know how to pronounce that, but that is not mentioned at all in here. Here it is just a case of doing an experiment on mouldy bread whereas with this you know that if people eat mouldy bread then the disease sets in.. Which is more scientifically based in a way because you've only got an experiment whereas with this one well you get mouldy bread. And how does the speed of it effect it You've been given the tables and the apparatus and the method. It is just all set out for you whereas that one you've got to design something like that
I: Which one do you think that you'd enjoy the most?
KK: this one...(recipe one)
I: OK so if you were given this with the next one... So the teacher gives you this one to go with it. What do you think of that one?
KK: now with this one it isn't as simple as the one before but because you know that this is somehow your method this is the sort of thing that you've got to do then I don't know a bit of common sense. Then you could probably put the method in the correct order and then if you followed the method you could get the idea of how your apparatus was supposed to be set up.... And then again with given questions you have just got to answer the questions and then you've got your arguments and conclusions and things like that so that one is all right I think.
I: so what would be happening in the classroom what would the teacher and pupils be doing in this?
KK: It would be the same as the last one working in groups and the teacher walking around and everything is done maybe checking after your method to make sure that otherwise you may not be doing a very good experiment but ... If you did something the wrong way round then something could happen so in that case she should maybe check to make sure that you'd understood the method, make you draw the diagram before you actually got into it.
I: What do you think about the subject of it?

KK: That is all right that is you put sugar in your tea so everybody knows about that so that is all right
I: OK that is quite interesting because perhaps the teacher might give you this one what do you think of this one?
KK:.....well at least on this one you are given factors to think about , its on a more on a fictional idea but again like the last one I personally prefer something where you are told what to do , to do it and then time for the questions rather than thinking well how am I going to do it? ...I think that that is about it.
I: what would be happening in the classroom?
KK: this would be more of a case of sitting around for the first ... When we did one in evidence we sat around and talked first and then kind of did a bit of trial and error. I don't know whether people want to do that and then get on with it type thing with the teacher walking around and viewing things maybe. Talking to you and giving you a few hints as you go along type of thing ...that is a bout it really....
I: and finally this one. What do you think of this first sheet?
KK: you are told what you have got to discover and your aim, you are not just doing it and then writing it up if you like read that and think about them. What you hopefully want to end up with ...I don't know I'm still keen on these than with your results and your method and your discussion. I just think that it is a lot easier at first you just do it and maybe keeping the aim in the back of your mind but not always and then answering the questions
I: What do you think of the subject material of the sheet?
KK: its .. Maybe not things that people come about much in everyday life. I mean you don't think about elasticity and elastic bands and things like that, but I don't know doing a thing like this then you can go onto gravity and forces and things like that. Just starting with a simple idea and expanding upon it. , But doing the experiment especially if you are doing it in individual groups.. You actually know yourself what happens to elastic bands and then doing your discussion later on which happens in the lessons in here. You kind of get more idea.
I: would you enjoy this one?
KK: I don't see why not it is not like really exciting but now I wouldn't be thrilled that we were doing something but ... I don't know it is all right . Its simple enough when you look into it further and there is more too it and I just like that idea, but it does sound a little bit boring but now I know that it is all right.
I: so instead of that one you get this one. What do you think of this one?
KK:....this one sounds a lot more like bungee jumping .. Seems a lot more exciting than that one, but.... Create a handbook for your assistant in simple terms again I don't know personally me I don't know about anybody else I prefer when set out for us and just having to do it. This one is a bit more thinking so I'm a bit wary about it. But I don't know I just think that that sounds a lot more interesting than just dropping... It is the same it is exactly

the same experiment. I don't know looking at elastic bands something like that, but how....
I: OK how do you think the teacher and the pupils would behave in this one?
KK: maybe the teacher would stand at the front at first and explain. It depends what age group you are working with not everybody knows about bungee jumping and how it is affected and things like that and just giving a bit of basic background and the things that you have got to do cause you can just try it with the elastic bands first and make things up. I don't.. And then it would be a case of getting them into groups and getting on with it.
I: How would these types of practical relate to the media problems? Do you think that this type of learning could be used?
KK: I think so doing experiments first and then talking about it is a lot easier because you have actually got some factual information that you've seen yourself. That is a problem of the media. People often believe too much of what they read with out having seen it for themselves, but I definitely think that doing an experiment especially something like elastic bands because then you can relate it to more complicated things like gravity and things like that it has been made a lot easier to understand doing practicals here
I: OK which ones do you think are the better ones these ones or these ones?
KK: for me these ones

SUMMARY- WHAT HAVE WE FOUND OUT?

I: This section will be the summary and I propose to clarify and expand upon the opinions that have been presented before.

I: If you were going to improve the image of a subject how do you think that this could be done?
KK: ...depends on the subject ...If you were to say like English then you could bring in more interesting books, you could do all sorts of things you could with English you could watch a play you could like go to a theatre like go to the cinema things like that. I think that you've got to try and sell your subject like just go back again to English people today not many are interested in looking back at it like the early century poets and things like that, but today there are so many good authors about that you can.. That are more interesting and actually mean something to people with a subject like geography you can always go out into the field and look at things yourselves so I don't know maybe it is the same with science ... Well explain things on a more basic level before turning complicated that is what happened at school it wads always the complicated stuff first and I had to learn it parrot fashion in order to understand it. I don't know making the subject itself sound interesting if possible. I don't know how
I: In a classroom, where pupils are advancing what should be happening? You have covered a lot of it before
KK: my mind has gone a blank.
I: I think that most of it you said before.
I: If a school topic seems very difficult what should be done?
KK: I think that it has to be taken back to the simplest level possible although some kids in senior school might think well why are they talking to us like babies for?... But a lot of the

time if you've gone in and said it in the most scientific terms possible then the kids are going to look at you and say what are you talking about, but going to the most basic possible without insulting them in your teaching I think is important and then just like building on that.. You put in an experiment or things like that or if you are doing geography then go out and have a look at that type of thing first

I: If a topic seems very boring what should be done?

KK: I think that it has to do I don't know whether peoples involved in an experiment or watching a film about it or I don't know because a lot of subjects are really boring you know what I mean. Unless they are thoroughly understood, but if it is a boring subject then you can't just sit there and teach it the kids have got to have something to put a bit of action into it.

I: If a school topic seems irrelevant then what should be done?

KK: well if it is on the national curriculum it is a bit difficult to completely avoid it especially as it could appear on the examination paper or things like that. Although it might not seem worthwhile doing I think it is important even if you just like if it is possible to tie it in with another topic which is pupils have seemed to enjoyed or ... Some subjects that are interesting you go onto a lot more detail. Maybe give the pupils enough knowledge to pass an exam or something like that if it is not worthwhile

I: How do you think that school should relate to what is required of people after they leave school?

KK: at school we had a lot of school career talks things like that. I definitely don't know whether.... well some things that we did in maths GCSE you thought I'm never going to use this again whereas if you talk about things like money people are always going to be involved in money so therefore if you say well in the future when you are doing this then you know how to do that then it would be a lot easier. I don't know maybe and try well try to relate things especially if its boring to get the pupils interested. I don't think that there was much that did relate well with history it is difficult except if you look back on things or if its something like geography populations and things just like how it is going to effect yourself in the future. I don't know people might look further ahead to....

I: you mentioned earlier that people have problems with confidence in science. How do you think that you can make those people more confidant school?

KK: I don't know if it is to do with the teaching method. I had an awful teacher in physics he just no matter how much you told him you didn't understand things he thought you were stupid. I don't think that there is any need for that and if the people lack confidence then try and get them to a level where they do understand it. It is a bit difficult with big class sizes but if the majority of the class are lost behind and lacking in confidence then you start at the lowest level. Even if they don't get to the top level then at least they have the lower levels to fall back onto.

I: OK thank you very much.

7.2.3 Appendix 2.3- example two

7.2.3.1 code dd first assessment transcription

7.2.3.1.1 Interview with DD

So to explain how we are going to do this interview. I want to know what you think about school and science. I have a sheet of questions to ask you some of the questions may include other information to help you answer the questions. There are three sections to the interview. I will record the interview so as to speed up the interview and as a memory aid. This interview is for research and as such is confidential. Is that OK with you?

INTRODUCTION- WHAT DO YOU THINK OF SCHOOL?

During this section I want to know what you think about school and in particular the subjects and people who were there.

After the initial questionnaire

For A level I see that you chose to do sociology, History and English Literature. Why did you choose those subjects?

DD: They were the ones that I enjoyed Well I enjoyed them at GCSE and I did all right in them. So.. I was originally going to do biology. But I decided to do sociology instead. I'm still not sure why but I did it anyway.

Did you have any difficulties choosing these subjects?

DD: not really people tried to pressure me into doing science but I just chose the ones that I enjoyed in the end.

What about the teachers of these subjects? Did that effect you?

DD: A few of them did yeah..

In what way?

DD: well I had a few favourite teachers obviously.. Especially in English.. And in History I didn't particularly like him because I'd had him since the first year. But I still chose History anyway. and a few of my science teachers I didn't particularly like. Probably made me not choose science.

What about the school how did that help you decide?

DD: .. They gave us a lot of guidance sort of careers wise, tried to find out what we wanted to do after school. And which vocation one wants obviously and what grades.. If we got good grades then they encouraged us towards them...

What about your friends what did they take?

DD: ..I think that that was one of the reasons that I went to a specimen sociology lesson because my friends were going to take it and I really enjoyed it so... Yeah that's probably why I took that... A lot of them did sciences instead of arts which is what I took really.... Which is quite strange but...

Why did they take sciences?

DD: A lot of them were very good at science and some of them just didn't like the other courses that were offered I suppose.

You mentioned specimen lessons. How were they done?

DD: Just before we went into the sixth form there was about a fortnight of specimen lessons where we took our final decisions on what courses we

wanted to do. So they just ran two lessons or so we previewed what we'd be learning.
How did they help you choose?
DD: well we got more of an insight into what the course would be because.. We knew the title and we knew more or less what the exam would entail. You'd know whether it would be interesting or whether it...
How did your parents help you decide what to take?
DD: Well my dad is a science lecturer so he really did want me to do science, but he was quite happy with what I chose and he is happy that I'm doing science now I think...
Were there any reasons why you didn't choose to do science that you can pin point?
DD: I don't know.. I just think that I enjoyed the other ones more.
Were there any other subjects that you would have liked to have taken as well?
DD: I did want to do psychology, because I thought that especially doing a teaching course it would come in handy later on. But it wasn't offered.... But apart from that...
What about your career? When did you first decide that you wanted to be a teacher?
DD: When I was probably about three, but it sort of wavered along the way but it is still there... There was my dad being a lecturer.
any other careers you thought of?
DD: ..at one point I wanted to be an archaeologist... And just I don't know things like that....
Looking back on the choices that you made with the benefit of hindsight would you change any of your choices?
DD: I would have liked to do a science now but I liked the course as we did it at GCSE with it being a general course I didn't like having to specialise at A level which is probably what put me off
What about GCSEs? How was what you took chosen for them?
DD: It was basically trying to fit them into the timetable more than anything else I got most of my choices but there was a few because the did offer a joint geography and history course, but I did them separately because I could fit more of the subjects that I wanted to do
What restrictions were placed upon you? What did you have to do?
DD: we had to do a language; we had to do a humanities subject... Like an art based subject and science.
Were there any changes that you would make as to how that was done?
DD: I would have liked to have had more of a free hand at things... After we'd picked a subject like we had our three core subjects we picked a humanities and a language there was then not much choice in what was left at the less popular courses.
Were there any subjects that you perhaps would not have taken?
DD: ... We were forced to do drama and music as a whole and I would have liked to have done those separately
How do you think the way that it was chosen affected the way that the lessons went in the classrooms?

DD: ...The ones that I'd been forced into I didn't really enjoy to start with but by the end of the forth year... I'd just accepted them then and I was just trying to do my best..

What sort of pressures were you under when you took your examinations?

DD: ... Well I felt quite pressured by the teachers because they were predicting me good grades because of my parents as well. I didn't want to disappoint and I suppose my friends as well because they all expected me to do much better than they did

How did you overcome these pressures?

DD: Just try to ignore them. They were not there.

Did that work?

DD: In some of them. In others the important ones like maths... And science and English I don't know how successful I'd have been if I didn't have the pressures

How do you think that the pressures helped you?

DD: I don't know I think that maybe they hindered me because if I was just doing them for myself. I wouldn't have been as concerned about them and I would have been able to relax more and revise better.

I: So that is the first section so if I go onto the second section

MAIN SECTION- WHAT DO YOU THINK OF SCIENCE?

I: During this section I want to examine the topic of science and the impression that it created in school upon you. I would also like to look at the media and compare the impression that is portrayed by the media to that in school

I:. W*hat import things happen outside school?*

DD: the main issues that effect the public and the way that they are handled like we are doing at the moment you sort of mean how it effects people in general..

I: anything that comes into your head don't think too much.

DD: I think that it bewilders most people The science things the way that they present the research and they have all these experts who talk about it and I think that a lot of people who don't have a science background. Officially like older women who were excluded from science in schools who don't really know much about it. It is difficult for them

I: OK what sort of topics is mentioned?

DD: It is the things that really effect the public like BSE crisis at the minute quite a lot of health things, scandalous issues and things that effect the whole of society.

I: How do you find out about other things that go on in the world?

DD: through newspapers, television, magazines

I: What things are going in on now in the outside world? You've mentioned some things already BSE anything else that springs to mind

DD: don't think that there is anything else I don't read papers

I: (How is science and the scientist portrayed by the media?)

DD:

I: Do you think that these things have any bearing on what happens in school?

DD: I suppose with the emphasis on BSE and things like that they may use that as an example in schools. I suppose with the stuff in the media about the falling standards and stuff they might ... Well you know try to raise standards really
I: How do you think that these things effect school?
DD: I don't know
I: do you think that well you mentioned falling standards do you think this might help schools?
DD: well I suppose it might they may try harder to get the stuff across, it just depends on the children really
I: Would you change the way the outside world relates to school?
DD: well its difficult because the impression they get of school as a parent is like they are really concerned for their child so I suppose that that could cloud their view a bit or they see it in the media. There is the falling standards issue there is the fact that the teachers aren't working well and well you know there is not much you can do about it.
I: I have three newspaper articles here. I'd like to have a look at them one at a time and would like you to comment on them. So I've got, I've got scientists warn of super AIDS bug. I've got major set to back ban on Handguns, and I've got food poisoning claims sixth life. Have a look at those if you would and say what you think of the topic.
DD: well to start with they have sort of said it as an epidemic, whereas there is only six people who have died from it. So it is sort of exaggerating it a bit and they have tried to make it a bit more serious by saying that there was over a hundred people at this party and could have been affected by it and the fact that the person who died was a seventy- two year old woman so it plays on the sympathies as she was elderly. There is a lot of statistics and things in it. You've got like the health boards and the ministry of Agriculture is in it as if they are experts and they know what they are talking about. .....Here again they have used scientists to make it sound as if it is a fact. What they have found can't be contested. They said that they have evidence to support it, but whether is it reliable or not you can't really tell and they have got statistics again and an expert at the bottom put a doctor in and the general public think well they must know what they are talking about. .....So they are going to trust Lord Cummings enquiry rather than the Commons report. So it would appear that his insight would be more valuable than the committee report ...so yeah....
I: What do you think the effect of the statistics is on the actual article?
DD:. Well if you see the statistics in papers then usually you expect them to be correct it is something that has been measured and its reliable because it has been tested. If it can be measure objectively then you think that it must be right. At least that's what the public expects
I: Why do you think that the newspaper has chosen to write about these topics?
DD: because they are in the public eye the public are worried about them so that they know that they will get a response. People want to hear about it.
I: Why do you think that people read these papers?

DD: because they are interested to hear what's going on and I suppose that they don't just buy any paper they buy the paper that reflects their own views
I: Which topic do you think is most important? Aids, food poisoning, or the banning of handguns.
DD: I'm not sure I think the way that it is put across in the press AIDS is the post important because that is the biggest threat, but the vast majority of the public they are more at threat from the food poisoning, although it is not given as much emphasis as AIDS.
I: Which one would you like to talk about AIDS or food poisoning?
DD: either
I: When did you start to take more interest in the news and newspapers?
DD: probably during GCSEs, when we needed examples for things and they encouraged us to get a better view OK....
I: Looking at the aids, food poisoning, handgun article when do you think that this becomes important to children today?
DD: what is terms of finding out about it?
I: yeah
DD: I don't know because earlier and earlier they are introducing the wider view of the news and also awareness like everything really I suppose. Maybe not in primary schools, but certainly once they get to secondary level
I: How should they find out about AIDS?
DD: I'm not sure because it is a big social issue but it is also a scientific issue maybe they should find out in say a sort of integrated sort of science also they could put in extra sort of information of a social nature.
I: How do you think the AIDS problem could be solved?
DD: well the thing is as soon as they find a cure for AIDS then something else is going to come along and this will be incurable or difficult to cure. I don't know maybe they should think more of prevention rather than cure
I: How do you come to those conclusions?
DD: ...I suppose it is through what I have read and the news and from doing topics about it at school and just general information. It is difficult to remember where you picked it up
I: How was science taught when you were at school?
DD:.. Well we were given a topic, a specific question to do with it we either did a little experiment or did a little experiment and then we were told the right results which aren't always right and then we learnt our lesson and got a theory from it..
I: Do you think that it was taught well?
DD: certain subjects were.. Others were a bit more dodgy, but it was OK. Some of the teachers we didn't like which was probably why we thought that certain topic weren't as good
I: Why do you think this was?
DD: I suppose that if you take a dislike for a teacher then you are not going to hold much respect for what they say and no matter how they try to teach it if it is not fun then you don't pay as much attention
I: One method of teaching science is to do practicals. How were practicals done at your school?

DD: well we were given the equipment and how to set it up. What to do what to measure and how to measure it then we went on with the experiment and then we got our table of results and drew a graph and then we were told what was supposed to happen
I: I've got three practicals that I would like you to have a look at. I'll start off with some equipment that might be used today. S what I'd like you to think about is what this equipment means to you and what would be going on in the classroom. So if I start with this practical. I've got three lots in all. So what would be going on in the classroom here?
DD: probably biology related lesson, or where you are just looking at cell structure or development of like a plant or something also if you were doing like earth materials or something you know when you do about volcanoes and things like that it sounds very geography related but we did it in science and .. Yeah things like that I suppose
I: OK. I'll get this one So what would be going on in the classroom with this apparatus
DD: probably like chemical changes or something.. Or maybe even just changing state, and solids and liquids and gases
I: anything else?.... Missed out this bit does that effect it?
DD: definitely chemical changes....
I: OK and the e final one that we have got.
DD: it is the physics related side, loads and rubber bands I know it well .
I: if you were given this sheet to go with this equipment here. What do you think would be going on in the classroom here?
DD: ...well you'd be .. I'd assume that they'd be .. Having looked to see how the mould develops on the bread and how it effects the structure of the can't think of any of the terms that we used to us there \
I: would you enjoy this one?
DD: ...it might be a bit boring, watching and sort of describing what it is like and how it is changing
I OK instead of this one you were given this one. What do you think of this one?
DD: ...well it looks a lot less scientific but it gives you a focus on why you are doing the experiment and there is sort of a parallel with everyday life so. It make is look as if it is actually a lot more worth while and its, ...
I: How do you think the teachers and pupils would behave in each one?
DD: ...in this one it is as if they are leading their own investigation whereas in this one it is as if it is a ritual. Where they get up the equipment and they do what they are told and they record their results
I; if we move onto the second experiment which was that one there. What do you think of this?
DD: ....again they have been given the list of everything that they have got to do it is just very scientific and sort of theory related I suppose .
I: What about the layout of the sheet?
DD: ...it is very organised you know and it is all in the right order of how to do the experiment and there is not much that you can really do wrong, just follow the instructions

I: OK if you were given this one instead?
DD: again it relates to everyday life. They are given things to think about rather than precise methods so that they can. So they can think of their own way to do it.
I: What about the layout?
DD: certainly looks more interesting than that one
I: OK the third lot, which is this one. So if you were given this. What do you think of it?
DD: again like it has got the results table it has got exactly how to do everything.. And what they need
I: OK what about the table
DD: well they know what to measure and which order to do it in. To record the variables of the experiment. They are not told exactly that these are the variables in the experiment, but they don't have to really think about anything. It is all there
I: and the final one this one here.
DD: well this one looks more exciting and its bungee jumping so it looks like it is more fun and..
I: what about the picture there?
DD: well it is exciting and it is fun and I think that they'd appreciate it more than that. It also makes them think more about what the variables are rather than having them written there for them. You have to think about what it is going to be affected by.
I: What do you think you'd learn from this type?
DD: This is more investigative. I mean they can make lots more mistakes but and I think that they find it more interesting
I: and what do you think that they'd learn from the other one?
DD: I mean they'd learn that this is what effects the experiment but I don't think that they'd remember it as much because it is written down there for them and all they'd have to do is get out a ruler, then rule, rule, rule and some weights and then record the results.
I: How would these types of practical relate to the media problems? Do you think?
DD: well what do you..
I: well would it be any use teaching pupils this. Would it help them with the problems outside school?
DD: Those practicals are a lot more related to the outside world. I mean they will think more about the considerations to take into account for the bungee jumper to be safe. Whereas if you just gave them a rubber band and ask them well what relationship does it have with the outside world then I don't think that they would be able to make the link. They realise that science has to be applied to the outside world.
I: well that is the main section. Now onto the summary section

SUMMARY- WHAT HAVE WE FOUND OUT?

I: This section will be the summary and I propose to clarify and expand upon the opinions that have been presented before.

I: If you were going to improve the image of a subject how do you think that this could be done?
DD: I'm not sure.. I think that the way that they split them up. I think before. I mean it is difficult too split them up because they overlap a lot but it is the fact that I had to specialise in one area or another. I wanted a more general picture because I didn't expect to be doing science as a main subject here ...so
I: In a classroom, where pupils are advancing what should be happening?
DD: they should be given more opportunities to investigate for themselves, I think. I mean from a personal point of view I skipped a year in primary school, but when I moved they put me back into the year I was supposed to be in with children my own age and so I definitely got more lazy only if they'd given me more opportunities to expand and work on my own. Then it would have been better
I: If a school topic seems very difficult what should be done?
DD: I suppose that it all depends on the intake that you have, but maybe there could be a simpler explanation that could be gained from it and maybe you could then build upon it.
I: what if a topic seems too easy?
DD: I think more opportunities should be given to investigate on your own. To go off and explore your own ideas and if you make mistakes then you will learn from that. A long as they are guided, as long as they are not just let loose
I: If a topic seems very boring what should be done?
DD: well like with the others if you link them with the real world and the problems that you face in the real world then they might appreciate it more. It is something that is relevant to them rather than just adults or for science
I: If a school topic seems irrelevant then what should be done?
DD: relate it to the outside world
I: How do you think that school should relate to what is required of people after they leave school?
DD: I'm not sure
I: OK well what do you get out of school?
DD: ...you get a general understanding of what is going on ... Alot of it doesn't seem to ... You learn a lot of subjects and a lot of them you think that you will never need. Maths unless you are going to do a maths degree, even at GCSE you wont need again. I suppose that simpler stuff should be done and concentrated on. Even if it accountancy or something like that
I: OK thank you very much. That is it.

7.2.4 Appendix 2.4- example three

7.2.4.1 code gg second assessment transcription can / won't

7.2.4.1.1 Interview with gg

7.2.4.1.2 Introduction

The interview is looking at your feelings towards science. I want to find out if they have remained the same or changed since before. Following this we will try to find out why it has changed or remained the same.

I will record the interview, for convenience and to make things quicker. Is this OK?

7.2.4.1.3 The Questions

I: How do you feel about science now?
GG: Not a great deal different from the last time that you asked me. I still struggle with the matter and interactions. Some of it is all right but some of it takes me ages to get grips with.
I: Are there any differences at all that you have noticed?
GG: not really no
I: Do you now think you could do science? (Even if it took a long time)
GG: to a certain degree maybe.
I: Have you ever thought that you could not do science?
GG: yes
I: Why was that?
GG: because I felt that I came her with no real background in science
I: Is it a 'possible' subject?
GG: yeah
I: Have you ever felt that science is an impossible subject?
GG: never impossible, just difficult.
I: Is there one bit of science that you are particularly happy about?
GG: I always felt happy about biology than say physics. Chemistry was always in the middle.
I: Are there any particular difficulties that you had with biology?
GG: not that I can think of.
I: Are there any bits of biology that you felt you did not learn and that you have learnt now?
GG: I don't think so it is rather just things that I've forgotten over the years and I've remembered them now when they have been brought to my attention.
I: I have two diagrams of pieces of equipment that might be used to illustrate scientific ideas (topics of burning candles and gravity). I will show them to you one at a time. I'll start with this one.
I: Do you think that you feel positive or negative about this?
GG: quite positive.
I: What sort of ideas would you use this to illustrate?
GG: the forces in the elastic band that is what we did last year.
I: anything else?
GG: no that is all.
I: OK. Did you have any problems understanding these ideas?
GG: I don't think so they were sometimes complicated to understand but I never really had any problems with them.
I: Were these ideas missing from before?
GG: yeah definitely
I: what sort of ideas?

GG: all of them.. Like I said the electric force we never had any of that . A lot to do with bonding. We were taught slightly differently from here. I don't think that I have the same understanding of it as I do now.
I: What sort of differences was there in the way that you were taught?
GG: I don't know really taught in basics terms. I think that at school it was a bit ambiguous in that it left you to think certain things when really. For example with bonding it taught you a lot about loosing electrons and then you find out that they don't actually loose them in the way that you were told at school.
I: OK if we go onto the second piece this. How do you feel about this?
GG: again it is something that we used last year so it is OK.
I: What sort of ideas would you use it to illustrate?
GG: I don't know I think like we did last year two gases brought together and a reaction because there is a flame and what happens when the flame goes out.
I: Did you have any difficulties understanding these ideas?
GG: No I don't think so.
I: Were there any missing parts from before?
GG: I don't think that I really touched them at all in school. So I don't ever remember doing it. So no. I was only ever told that a flame needed oxygen and that was it.
I: Is there anything else that you can remember?
GG: no not really.
I: Why didn't you understand these ideas before, do you think?
GG: I don't think that it was about understanding the subject. It was more about learning the facts about it to pass the exams. That was it really. I don't really feel that it was to do with understanding so a lot of it I didn't understand
I: What do you mean by understanding?
GG: well you tended to learn that things did happen not why they happened or what brought them about. It was just basically learning that they did happen. I think.
I: When you said that they weren't taught 'why' things happen. Why do you think they taught you that way?
GG: I don't know I suppose that there was just a short space of time in which to to cram everything in. They just gave you what you needed to know and that was it.
I: Would you want to do more science now, if you could?
GG: I don't think so.
I: Why not?
GG: I think that this is a level that I can get to grips with but any further it would be pushing.
I: Would you like to make any other comments?
GG: no
I: well thank you very much for your time

7.2.5 Appendix 2.5- example four

7.2.5.1 Code ww second assessment transcription can / will

7.2.5.1.1 Interview with WW

INTRODUCTION

The interview is looking at your feelings towards science. I want to find out if they have remained the same or changed since before. Following this we will try to find out why it has changed or remained the same.
I will record the interview, for convenience and to make things quicker. Is this OK?

THE QUESTIONS

I: How do you feel about science now?
WW: I understand it much better since the matter and interactions course. Because I actually understand the principles rather than just the words and such stuff. It is much more interesting and less scary.
I: Is this different from/the same as before?
WW: It is different from what I thought of it at school because I guess I wasn't taught as well at school. And so my view of science has improved.
I: Why do you think that you weren't taught as well at school?
WW: because it was taught through a textbook to pass an exam it wasn't taught for understanding. It was taught to get grades.
I: Do you now think you could do science? (Even if it took a long time)
WW: yes I could do it better. Not greatly but better.
I: Why do you think that?
WW: because I think that it helps with me because I didn't understand it so well before. Now that I've been taught well I can relate to people who don't understand it and teach them in the ways. I deal with it much better than I could before.
I: Has there ever been a time when you thought no I couldn't do this?
WW: yeah there have been a lot of times where there have been words and kind letters and numbers all shoved together. I just have no idea.
I: Is it a 'possible' subject?
WW: yeah definitely. I think that anybody could do it if they are taught with understanding and with the basics. And check that they understand it throughout then they will begin to understand it more than they used to.
I: Have you ever thought of science as being impossible?
WW: yes
I: what now?
WW: well when I was at school. I mean physics for example I never even touched. I was just told that I would never be able to do it. Well and chemistry ... Well I was all right at biology, but chemistry and physics were just all too intense.

I: Is there one bit of science that you are particularly happy about?
WW: I'm just more happy about the basic principles of atoms and molecules. Just the basics of everything. Attractions and repulsions. I mean I just didn't know anything about that before. So everything you can build on from those principles.
I: Which bits of this were a problem?(when trying to understand this idea?)
WW: I had no idea because we just weren't taught the principles. We just got straight into the kind of processes. Electricity and this that and the other thing and you never got why. It was just learn this and this is what happens.
I: Were they missing bits before you mentioned 'why'?
WW: Well things like the living world... We were just talking about homeostasis and how it refers to loads of different things, but with school it was kidneys, homeostasis that was it.
I: I don't understand it, but go on.
WW: I can't explain it very well but basically it is about bringing stuff back to the norm and all different cycles and stuff. With kidneys bringing the body back to the norm. Word like that I just referred it to one set thing and it was in the textbook for the exam. Instead of a word commonly used for loads of other things.
I: So that wasn't there before.
I: I have two diagrams of object that might be used to illustrate scientific ideas (topics of burning candles and gravity). I will show them to you one at a time.
I: Do you think that you feel positive or negative about this?
WW: It relates to the weight and the band and how the band holds it up.
I: Do you feel positive or negative towards it?
WW: I feel positive towards it?
I: Which parts of these ideas were problems when you tried to understand these concepts?
WW: straight away I wouldn't actually think of the actual make up of the rubber band. I would thing of gravity and that was it. I would just think that the band holds it back. I wouldn't know why. I wouldn't know the equilibriums or anything like that. I would just think immediately. That's a weight and it pulls down. It would just stop it from falling basically. I had no idea why.
I: What about gravity.
WW: I just thought of gravity as something that pulls you down. And nuclei just the whole concept of gravity. I only knew it as a word. I never understood it. But now I do but I can't understand it very well so don't ask me.
I: OK the second one I'll probably get wax all over the place again so... How do you feel about the scientific ideas that are brought into play here?
WW: I can't remember my stuff from last year to do with it. I just would never have known about what a flame is. What happens with the reaction to the wax. The wax melts, goes runny. That is just what happens. I can now look at that and say oh look what is going on rather than oh look there is a candle burning. It is interesting because you can apply science to things that

you know and understand what is going on. So you can actually relate it to stuff. That you do know about.
I: Which parts were problems that you haven't mentioned.
WW: I'm not good with candles still. When my notes aren't very good I still don't understand it that much.
I: Which bits don't you understand?
WW: I just don't understand flames basically. What flames are why they react? I know that it is something to do with the wax. I know that it is a reaction with wax and oxygen something like that. But I don't understand why this flame... What this flame is.
I: Were there any missing parts from school that you definitely didn't learn?
WW: I really didn't do that much science ... Chemistry and physics at school because I was told that I wouldn't be able to do it. I was told that it was too mathematical. I was always better at geography and biology that I could apply .. Relate it to stuff around me, which is kind of. Actually I thought of physics being like figures that I couldn't understand I didn't understand that it was happening all over the place that you could relate it to.
I: Why didn't you understand these ideas before, do you think?
WW: Just what I said before ... Just mind-boggling numbers that would shut my brain off ... I just didn't understand it. I had a real negative view about it.
I: Would you want to do more science now, if you could?
WW: yes I mean I love this course. I love.... I chose science as my main subject.. I just saw principles and thought oh that sounds good. It is brilliant I love this subject. Even at the beginning of last year I thought I'm not going to be able to coup with this. But then you realise that you can. You think well this is quite difficult but then you work through it. It does come out OK in the end
I: Would you like to make any other comments?
WW: no not really apart from I feel that primary science should be based upon stuff that the kids can apply their brain to rather than some difficult subject that only the boys can do who are very very clever.
I: Ok thank you very much for your time.

7.2.5.1.2 Additional information obtained from end of year course assessment

Some examples of written responses to the question 'What have you gained from this course?'

"A deeper understanding of science + some much needed SELF-CONFIDENCE"
"Depth in some basic scientific issues. Learning from basic levels upwards"
"Enjoyed it- don't' usually enjoy science. Made scientific ideas a lot more simple"
"Cleared up a lot of grey areas from previous science education"
"Refreshed science memories from GCSE, enabled me to continue learning + practising science techniques"

The students were asked to respond to the question 'Would you recommend this course?' by placing a circle on a six-point scale ranging from very strongly to not at all. The frequency of each of these responses is given below. (Number of completed questionnaires was 48 out of a possible 74).

scale	very strongly 6	5	4	3	2	not at all 1	no response
frequency of response		15	5	0	0	0	3