Understanding and Developing Student Interest in Science: An Investigation of 14-16 year-old Students in England

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Declaration:

I, Helen Margaret Darlington, confirm that the work presented in this thesis is my own. Where information has been derived from other sources, I confirm that this has been indicated in the thesis.

Signed: H. Darlington

Dedication:

For Sidney, started because you didn't exist and finished because you do. May you always find the world full of interest and wonder.

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Firstly, I would like to express my sincere gratitude to my supervisors Prof. Michael Reiss and Dr Paul Davies for the continuous support of my PhD study, for their patience, motivation and immense knowledge. Their guidance helped me in all the time of research and writing of this thesis. I could not have imagined having a better supervisory team for my Doctoral study.

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I am grateful for all of the students and teachers I have had the pleasure to work with over the years. In particular, I must thank those who were willing to participate in my research, without whom this study could not have taken place nor developed in such a meaningful way.

Abstract

The aim of this research was to investigate what can be done to develop student interest in GCSE science lessons. Mixed methods were used to develop an understanding, and allow comparison, of the views of groups of students and teachers. Students were asked what they believed to be the purpose of learning science between the ages of 14-16, how interested they were, and what they believed could increase their interest, in science lessons. A questionnaire was completed by 475 students and 11 teachers from four state-maintained schools, in England, in the summer before the students started their GCSE studies. Lesson observations and focus group interviews were carried out in one school over a period of two years. Two classes of students completed a second questionnaire at the end of their GCSE studies to assess their interest level.

Student responses to the question generated six Interest Factors and four Purpose Factors. There were minimal differences between the strength of agreement with these factors from male and female students but significant differences in the responses of students from different ability sets, a trend seen in all schools. There is a mis-match between the beliefs of teachers and students as teacher responses mirror those of the students from the highest ability set only. The findings also suggest a strong relationship between students' levels of interest in science lessons and their relationships with teachers.

There are clear relationships between the level of interest a student has and where they see the influence and responsibility for developing that interest lies, whether with the student themself or with the teacher. Through subtle but significant changes to pedagogy which incorporated the Interest and Purpose Factors, generated as part of this research, it was possible to increase student interest in science lessons during the two years of study.

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Chapter 1: Introduction

The importance of engaging students in their learning cannot be denied. If a student does not want to learn, they will not learn much. It should therefore be a key aim of educational research to investigate how the learning environment can be optimised to support student engagement to allow students to make cognitive and appropriate affective gains. These investigations should cover not only the importance of the physical environment but also the less tangible aspects of the classroom such as the teaching and learning activities and the relationships formed between teachers and students. A wide range of factors will influence student engagement with their learning. Some factors will be social in nature: the engagement of the peer group, parental attitudes or teacher-student relationships. Other factors may be a result of an individual's personality, for example, if they are naturally curious or confident at taking risks they may be more engaged with new subject matter than are other students. Finally, factors such as a student's perception of the relevance of activities or content may also influence their response to the subject. The right combination of these factors may lead to a student being fully engaged in their learning and, through increased effort, result in them furthering their knowledge and understanding. Interest, whilst not always being considered necessary, is understood to both contribute to and result from student engagement in learning.

Student interest and engagement with particular subjects will wax and wane throughout their school careers as the nature and relative importance of the influencing factors vary. One curriculum area where there are currently particular concerns is that of science and how student interest and career aspirations with regards to science change throughout their school careers (DeWitt, Archer and Osborne, 2014). At a national (indeed, international) level this has raised the question of where the next generation of scientists and engineers is going to come from and the potential impact of any shortages on the economy. It is therefore timely to investigate what factors influence the development and sustainability of students' interest in secondary science lessons (14 to 16 years). For many students, this is the last time they will engage formally with learning science, although increased interest may increase the number of students who continue with science study or complete this study with more positive attitudes towards science.

1.1 Personal background

When I started my doctoral study in 2011 I had been teaching Science, Biology and Psychology for eight and a half years in a high achieving secondary school in Cheshire and continue to do so. Throughout my teaching career I have taught all ages (11 to 18) and the full range of ability groups in my school. Specifically, I have taught a number of different Key Stage[1] 3 courses (ages 11 to 14) and I have taught the biology components of different courses, from different examination boards, to Key Stage 4 classes (ages 14 to 16), including Biology GCSE, Double Award Science GCSE, GCSE Science, GCSE Additional Science, GCSE Applied Science (2 year course), GCSE Additional Applied Science, BTEC in Applied Science (1 year course) and BTEC in Applied Science (2 year course). I have also taught AS and 'A' levels in Biology, Human Biology and Psychology to a large number of students post-16.

One of the things I have found most enjoyable is being able to get students interested in science and seeing the expressions on their faces when they become fully engaged with the subject for the first time and realise that science can be relevant to their lives. I have been intrigued by how students have responded to the differing

[1] The National Curriculum for England is arranged into 'Key Stages', at the end of which students are formally assessed. The majority of secondary schools contain two Key Stages: Key Stage 3 includes students aged 11 to 14; Key Stage 4 includes students aged 14 to 16, with some schools also delivering post-16 courses (Department for Education, 2017).

content and delivery style of each of the courses I have taught. The Key Stage 4 courses all purport to fulfil common aims of 14-16 science education, as laid out by the appropriate incarnation of the National Curriculum (for example, Department for Education, 2014). However, they all take different approaches based on different principles. It has made me think about the importance of tailoring teaching to the interests and needs of different 'types' of students, remembering that a class is made up of individuals rather than being a homogenous group of blank, or half written, slates.

The relationships I had, and have, with my parents and teachers have supported the development of my interests in science, education and research. From a personal perspective, my fascination with science, in particular biology, was supported throughout my childhood by engaging in a number of activities such as 'rock-pooling', learning the Latin names of mosses and 'playing' in science museums. The most vivid part of these memories, however, are the people who introduced me to these activities; the fun we had exploring and talking about what we were doing – I cannot remember ever being told to stop asking questions or being told that the answer did not matter. One memory is particularly prominent for me when I consider what triggered my interest in biology. When I was about 12 years old I was sitting on my parents' bed talking about facts versus theories when my mum explained the endosymbiotic theory of cell evolution to me. This theory was so elegant and mysterious (although I think the word I used at the time was "cool") that I wanted to find out more both about the theory and about how people can be so creative in developing such theories.

However, I never felt pushed into these fields; no paths were blocked, instead my interests have been accepted and nurtured. In the same way, my twin sister was always encouraged to pursue her non-scientific interests, in particular history, despite her aptitude for science and the scientific backgrounds of our parents. This, to me, highlights the importance of allowing individuals to explore their own individual paths and discover (and create) their own interest. A teacher's role, therefore, should be to afford students the opportunity to develop interest rather than direct them, either consciously or subconsciously, down a different path as a result of poor quality teaching.

Throughout my teaching career I have been able to explore wider aspects of teaching science: enrichment and extension activities; transition between primary and secondary school and extra-curricular activities, all of which have fuelled my passion for engaging students in learning science and questioning the world around them. In addition, as part of the school's 'Leading Edge' work, I undertook some small-scale research projects within my school into influences on students' engagement in lessons. This work, ultimately, led to my doctoral study which forms the basis for this thesis (Darlington, 2012).

Early on in my teaching career I became interested in using student views to inform my teaching and delivery of the courses. As I became more confident as a teacher and built strong student-teacher relationships my students became more confident in discussing their learning and my teaching in a reflective manner. This was especially the case by the end of my fifth year of teaching by which time I had taught some students for four out of those five years. I recall that some of these experiences were extremely positive; for example, in 2011 one of my Year 10 students proclaimed "this is actually quite creative!" as we were building a model of a bacterial cell out of cable and pipe-cleaners. Her tone suggested surprise, although I cannot be sure whether this was at my creativity or at the realisation that science could be creative. This activity clearly triggered her interest and she and the class were more diligent in completing the activities that followed than they had been in previous lessons.

Unfortunately, some of discussions I have had with students regarding teaching and learning have not been so positive and these experiences have developed my understanding of how to use student voice effectively. It is important that those working with students to collect student views have good relationships with them and that responses are assessed for reliability either by collecting a large amount of data or through triangulation with other forms of data. It is equally important that others, particularly teachers, be given a voice and a platform to ensure that communication is not one way.

I was also intrigued by the reactions, both positive and apprehensive, of colleagues to the increasing use of 'student voice' within school, although if they have experienced the same range of responses from students this is understandable. One barrier to the acceptance of the use of students' responses came as a result of the management of the first major student voice initiative within my school. An outside research company issued questionnaires to a large sample of students and parents and conducted a number of student group interviews. The data were then presented to teachers, with little or no contextualisation or indication of frequency of certain comments, a number of which were negative. Needless to say, staff felt cut off from the process, unvalued, muted and judged. Since then 'student voice' within the school has evolved: it no longer means students moaning about teachers on anonymous questionnaires, and it continues to evolve. The phrase 'student voice' is now used as a blanket term for a whole range of activities from teacher-led surveys to students planning whole or parts of lessons as well as student involvement in the interviewing of potential new staff.

With the increasing use of student voice, I became struck by the fact that the views expressed by my students were not necessarily consistent with those of my colleagues and myself. This, in turn, led me to consider the importance of communication between teachers and students. Obviously, teachers develop methods of effective communication in order to teach students the knowledge and skills required for the course and to develop their understanding. However, there may be times when teaching becomes focused solely on fulfilling the examination criteria and communication regarding the wider issues of teaching and learning, such as the role of dialogue in learning, is lost. The possibility of investigating the different modes of communication between teachers and students within the classroom appeals to me. However, since this is a vast area I realised that it must be narrowed down to a more specific focus for doctoral study.

Over the last five years I have worked with teachers to investigate ways of developing their classroom practice and increasing student engagement. To this end, I have been involved in establishing an effective peer-coaching programme within my school which includes all members of teaching staff each year. This is very rewarding and I find the best ideas result from discussions with colleagues where all feel confident and relaxed enough to suggest creative solutions for use in teaching. The success of this work suggests that involving teachers as participants in research can result in valid data, which are less likely to be affected by researcher bias and also benefit more people since, it is hoped, the teacher will benefit as well as the researcher and the students.

My reflections led me to focus on student interest in science, starting with an investigation into what elements students find interesting in science lessons and whether or not teachers have any awareness of these. I am also interested as to whether there are links between other characteristics, such as gender or ability level, and a student's level of interest in science lessons or in science as a subject. I began to wonder if, once I had developed more of an understanding of these areas, I might be able to work with other science teachers to investigate what can be done in the classroom to develop student interest.

1.2 Rationale for studying interest in school subjects

Life would be dull, by definition (Oxford English Dictionary, 2017), if there was no interest. It is interest that drives our curiosity and therefore, I would argue, it is a key force in driving our learning and discovery of new knowledge and deeper understanding. As a result of this, the relationship between interest and learning has been investigated since the start of the 19th century (Krapp, Hidi and Renninger, 2015). Research into various aspects of interest has continued since then and towards the end of the 20th century there was a move to look at interest as an "explanatory construct" as well as considering the "influence of interest on learning and development and the origin and transformation of interests" (Krapp, Hidi and Renninger, 2015, pp. 4-5). The reason for this is the growing body of evidence which indicates that interest has been shown that increased interest in a subject can increase student attainment (Hulleman and Harackiewicz, 2009). Furthermore, it can have a profound positive impact on an individual's attention levels, recall of information, persistence and effort in the pursuit of knowledge (Hidi and Renninger, 2006; Krapp and Prenzel, 2011; Mitchell, 1993), all of which are important for the individual and for classroom practice.

Interest is, at times, an elusive and fickle beast, difficult to find, hold on to and understand. As social beings who construct some of our knowledge and understanding of the world through communication with others (Crotty, 1998), it is not surprising that interest in a subject area is strongly influenced by the people around us and the relationships we form with them (Rodd, Reiss and Mujtaba, 2013). Often a teacher is the key person who plays a role in triggering and nurturing interest for a particular subject. Those who have seen films such as *Dead Poets Society* (1989), *Mona Lisa Smile* (2003) or *The History Boys* (2006) are either lucky enough to somewhat identify with the characters, remembering their own inspirational teachers, or watch wishing they had been able to experience teaching like that.

Teachers do not have to be as flamboyant or radical as the examples in these films in order to support the development of student interest; however, there may be common traits or approaches to teaching which are more likely to capture the interest of students. Many people can reminisce about their own, more tempered, experiences that triggered interest in a subject area.

Key features of Individual Interest are the desire to re-engage with specific content and the feeling that, despite being challenging, the learning of new information is effortless. Therefore, having an interest in a subject improves an individual's chances of increasing their knowledge and understanding of a subject as they are more likely to devote time and effort to learning the required content.

The need for students to see activities as meaningful is a supportive factor of interest development which appears in most interest research (for example, Krapp and Prenzel, 2011). Evidence from studies (such as Mitchell, 1993) showing that students need to understand why a specific activity is important has led to a greater emphasis being placed upon involving students in a dialogue regarding lesson objectives and learning outcomes and how these link to the lesson activities. Few if any studies, however, have explored whether there is a need to see the activities as meaningful in order to support student interest in a subject. It may be that if students understand why they are doing a particular activity, this will only help to trigger interest for a short period of time. It may also be the case that if students have a clear understanding, not just of why they are doing a particular activity, but also of the purpose for studying a subject for a specific qualification, for example, for GCSE, this will contribute to them developing a deeper, longer-lasting interest. The impact of this may be particularly important for subjects which are deemed compulsory for all students to the age of 16.

As with student engagement there are a number of factors which could support the development of a student's interest in a particular subject (Hidi and Renninger, 2006). However, there are also broader factors which may influence the likelihood of a student being interested in a subject at all. One such factor is that of gender. The causes of gender differences have been explored for over a century (Hyde, 2014) and the impact that gender differences have in a large number of fields is often debated. There is some evidence to suggest that there are some underlying gender differences with regards to what will trigger interest (Ainley, Hillman and Hidi, 2002); however, the cause of these differences in unknown. Another of these broad factors, albeit one which has been relatively neglected by interest research, is that of ability or more specifically the impact of the judgement and categorisation of a student's ability when they are placed in a specific 'set/class' in school. Anecdotal reports from teachers often refer to a lack of interest from students put in such 'lower ability' groups. If true, this may be a result of these students lacking knowledge and mastery in an area (Alexander, 2004) or perceiving the work to be too challenging for them (Deci, 2015). Alternatively, these students may have a low self-concept of their ability in a particular area. Hallam and Deathe (2002) found that students in lower ability sets were more likely to be called names by their peers and felt they were respected less than students in higher sets.

1.3 Rationale for studying science and science education

Current theories of Interest agree that interest cannot exist without a subject; something to be interested in (Hidi and Renninger, 2006; Prenzel, 1992; Schiefele *et al.*, 1983). Therefore, to investigate interest there needs to be a subject, which in the case of this thesis is science, specifically, the domains and topics which are taught as part of the Key Stage 4 (for 14 to 16 year-olds) National Curriculum in

England and Wales. The reasons for this are two-fold: first there are concerns, on a national level, about the interest levels of students in science; and second to help further my own understanding of teaching science.

For well over a decade concerns have been raised by UK governments, universities and businesses about the lack of students studying science subjects at ‘A’ level (post-16) and university level as well as concerns regarding how few people are choosing science or STEM-based careers. As a result, there have been a vast array of studies which aim to investigate why students are not choosing science (for example, Archer *et al.*, 2013; Murphy and Whitelegg, 2006). Although a number of different issues have been identified, such as the perceptions of science/scientists and a lack of awareness of STEM-based careers, a recurring theme is the reduction of student interest in science as they progress through secondary school. Studies have also highlighted the issue of gender differences with regards to interest in science (Jones, Howe and Rua, 2000).

From a teacher’s perspective it is so much more rewarding to work with a class of students who are interested in the subject matter you are trying to teach them. Interested students, who are deeply engaged in their learning, are likely to exhibit fewer undesirable behaviours therefore allowing themselves and their peers to make better progress. It is therefore the task of teachers, as Krapp and Prenzel (2011, p. 44) state:

> . . . to pick up the interest which the students bring with them, i.e. to establish connections between it and the curricular requirements. These interests can relate to context, content, and activities. Thus, an elaborate conception of interest and a diagnostic way of looking at things are important aspects of science teachers’ competency.

Therefore, developing teachers' understanding of what contributes to levels of students' interest in science has a contribution to make, not only to the quality of science education but also to addressing wider economic concerns.

1.4 Context for the study

Much of the research into factors which support the development of interest have focused on the nature of text-based resources (for example, Wade, Buxton and Kerry, 1999), with relatively few studies taking the approach, adopted by Mitchell (1993), of investigating how the interest of students is supported in classroom settings for a particular subject. In a similar vein to Mitchell's study I am interested in what factors support the development of student interest in a highly contextualised classroom setting. However, instead of looking at mathematics lessons the subject focus of this thesis is science lessons. The age group of students chosen was 14 to 16 years of age, the last two years of their compulsory science education and therefore the last two years of science lessons for many students. Furthermore, it is generally accepted that students' interest levels have decreased between them starting secondary school aged 11 and them starting Key Stage 4 at the age of 14, with many students reporting further declines in interest to the age of 16 (for example, Archer *et al.*, 2013; Murphy and Beggs, 2003).

Teachers from four secondary schools (see Box A in Chapter 3, pp. 83-84) agreed to take part in this research. All these schools are located in the North West of England and follow the National Curriculum for students aged 11 to 16 years. All students from School A and a sample of students from the other three schools agreed to complete a questionnaire, in the summer term before they started Key Stage 4 study, to provide reliable data on student interest levels, the factors they believe influence their interest in science lessons and their perception of the purpose of learning science at this stage of their school careers.

In addition, a sample of students and teachers from School A agreed to take part in focus group interviews and lesson observations to allow qualitative data to be collected and, through considering teaching practice, provide an opportunity to investigate if adjustments to teaching can influence students' interest levels. This work was conducted in conjunction with the teacher participants from School A. This engaged teachers directly with reflective practice in order to consider ways in which they might increase the efficacy of their practice. For some teachers, this fulfilled a goal of education research.

The data collected were scrutinised with regards to gender and ability setting of the students. However, any influence that ethnic differences may have on student responses was not considered as the vast majority of students in all four schools are of white British background.

1.5 The structure of the thesis

Since I was intimately involved with the data collection activities, particularly the reflections on my own lessons, it would be artificial to remove myself from the thesis by writing in the third person. Therefore, this thesis is written in the first person in order to reflect my role as a participant researcher.

After opening with a discussion of the arguments for the importance of researching 'interest' in educational settings, in Section 2.1, the literature review continues to present three current theoretical understandings of 'interest' (2.2). As described above, the 'object' of interest under investigation in this thesis is that of 'Science'; therefore, the reasons why school students in England and Wales are required to study science up to the age of 16 are discussed in Section 2.3 as a clear sense of purpose and meaningfulness is strongly linked to a high level of interest. The remainder of Chapter 2 explores other factors that may influence students' interest in learning science, specifically individual difference (2.4) and cultural influences grouping (2.5), as well as exploring how the development of interest in studying science can be supported (2.6). A central theme of this work is the views of students, with regards to their interest in learning science. The literature review therefore closes with a consideration of what research tells us students think about their science education (2.7), and an overview of the study and the research questions which emerged (2.8).

Chapter 3 presents the epistemological standing and methodology (3.1) underpinning this thesis as well as outlining the data collection methods used (3.2 and 3.3). In addition, there is a detailed discussion of the ethical considerations in light of this research taking place in the school in which I work (3.4).

The results of the main study, and discussion of these results, are presented in Chapters 4 and 5. The data collected from the student questionnaire were used to assess the levels of both Situational and Individual Interest of the students who completed it (4.1), as well as generate Interest Factors (4.2) and Purpose Factors (4.3) which described the key factors students believed may increase their interest in learning science and what was the purpose of learning science respectively. These three aspects of quantitative analysis are supplemented by data collected from lesson observations and focus group interviews to provide deeper understanding of students' feelings, attitudes and beliefs. Section 4.5 uses correlational analysis to explore possible relationships between students' interest levels and their agreement with both the Interest Factors and Purpose Factors. The second half of Chapter 4 discusses the results presented on interest levels (4.5), Interest Factors (4.6) and Purpose Factors (4.7), followed by the key conclusions which can be drawn from these discussions (4.8).

Chapter 5 is structured in the same manner as Chapter 4 in that the first sections present findings and the second half of the chapter discusses these findings in light of existing research. Throughout it builds on the work presented in Chapter 4 but explores the data with respect to differing groups of students. First, Section 5.1 presents the differences in responses from students from the four schools involved in the study. Second, Section 5.2 focuses on the responses from students in different ability groups (classes) within the four schools and, finally, Section 5.3 presents the gender differences found for levels of interest and agreement with the Interest and Purpose Factors. Following the presentation of these findings is a discussion (5.4) which follows the same sequence with a comparison of the students depending on their school, ability group and gender. The final section of results in this chapter presents a comparison of the students' responses to the responses given by teachers with regards to the levels of agreement with the Interest and Purpose Factors (5.5) and is followed by a discussion of these findings (5.6).

Chapter 6 describes how the teacher participants and I worked with two classes of students to investigate whether or not it is possible to increase student interest through acknowledging students' attitudes towards interest in science lessons and adjusting approaches to teaching activities. There is also a discussion of how the Interest Factors can be, and were, used to enhance practical work tasks in an effort to support the development of student interest in lessons and increase the learning which takes place during such activities. This work took place through the use of rigorous reflective practice in the context of a normal working school over a period of two academic years.

The final chapter, Chapter 7, draws together the key findings from the current study and relates these to theories of interest. It also includes is an evaluation of the study and a discussion of areas where further research is needed.

Chapter 2: Student interest in science lessons – literature review

2.1 Introduction: motivation and interest

Teaching effectively and supporting students in learning a new skill or understanding a concept is a complex science and an intricate art full of subtly, and often, mystery. Similarly, there are a myriad of achievements which may be used to identify whether or not someone is a 'good' teacher. In today's society where everyone is target driven one of the key goals of a teacher is to support students to achieve their (academic) potential. This is clearly embedded in the Teaching Standards published by the Department of Education in England which, among other things, require teachers to:

1. Set high expectations which inspire, motivate and challenge pupils
   - establish a safe and stimulating environment for pupils, rooted in mutual respect
   - set goals that stretch and challenge pupils of all backgrounds, abilities and dispositions
   - demonstrate consistently the positive attitudes, values and behaviour which are expected of pupils
2. Promote good progress and outcomes by pupils
   - be accountable for pupils' attainment, progress and outcomes
   - be aware of pupils' capabilities and their prior knowledge, and plan teaching to build on these
   - guide pupils to reflect on the progress they have made and their emerging needs
   - demonstrate knowledge and understanding of how pupils learn and how this impacts on teaching
   - encourage pupils to take a responsible and conscientious attitude to their own work and study.

(Department for Education, 2011)

These key standards apply to all teachers in the training stage of their careers as well as all teachers working in maintained schools in

England (Department for Education, 2011). The above quotation highlights how multifaceted the simple statement of ‘support students to achieve their potential’ actually is as all of the points above can feed into this over-arching aim. This complexity is also reflected in the variety of ways in which different countries have attempted to capture the essence of teaching in their own “teacher standards” (see, for example, Wyatt-Smith and Looney, 2016).

However, defining the characteristics of good teachers and their practice is only one aspect of understanding what contributes to effective student learning. The role of the teacher is important but what is usually described as ‘teaching’ is only part of the story. As Alexander (2010) argues, the use of the term ‘pedagogy’ in its widest sense is more appropriate to include both what happens in the classroom (both teacher and pupil tasks) and the ideas and values that inform the practices.

While improving our understanding of pedagogy is important, it is just as important to understand the learning process from the students’ perspective. Their reactions to the experiences offered during lessons play an important part in determining the quality of their learning and the level of their achievements. A key aspect of student learning is that of their ‘motivation’ to learn. There are a number of different definitions of motivation available in the published literature, including “a reason or reasons for acting or behaving in a particular way” (Oxford Dictionary Online, 2017), “the willingness to attend and learn material in a development program” (Cole *et al.,* 2013, p. 67) and “the energization (i.e., instigation) and direction of behaviour” (Elliot and Covington, 2001, p. 73). These definitions can be considered broad and descriptive and as such are of little use when considering how best to increase students’ motivation. It is therefore necessary to focus on explanatory theories of motivation for the purposes of research. It is widely accepted by psychologists that there are two general types of motivation: extrinsic and intrinsic. According to Deci and Ryan's (1985) *Self-determination Theory*, extrinsic motivation is doing something because it will lead to a particular outcome, for example, a financial reward or good grades. Intrinsic motivation, however, is doing something because it is "inherently interesting" (Ryan and Deci, 2000a, p. 55). *Self-determination Theory* proposes that in addition to Situational Interest, which it considers to be the only form of intrinsic motivation, there are numerous extrinsic motivators which may cause an individual to engage with an activity they are not interested in. Over time, the individual may integrate these extrinsic motivators, leading to self-determined regulation of the activity, which, in turn may lead to increased interest in that specific behaviour (Deci, 2015). Originally proposed in 1985, this theory has been extremely influential in the field of education research and is still used as a basis for a significant amount of empirical research. However, *Self-determination Theory* is still broad, encompassing the whole area of motivation. It was therefore decided for focus in further and look at one particular aspect for the purposes of this research, namely *Interest.*

There is a growing body of research, as discussed in this chapter, which suggests that increasing student interest in subject matter can make a significant contribution to students' achievement through increasing both their positive affective and cognitive engagement with the subject content. For example, increased interest boosts intrinsic motivation (Schraw, Flowerday and Lehman, 2001) and can increase attainment (Harackiewicz *et al.*, 2014; Hulleman and Harackiewicz, 2009). Other studies (Hidi and Renninger, 2006; Krapp and Prenzel, 2011; Mitchell, 1993; Wiseman and Hunt, 2013) suggest that the benefits of developing interest include more focused attention and the enabling of integration of prior knowledge as well as having a positive impact on a range of abilities such as recognition, recall, persistence, effort and academic motivation. It was a desire to explore further the effect of student interest that was the starting point for the study reported in this thesis.

2.2 Interest: Definitions and models

In order to understand the scope of the impact of what might be referred to as 'generic interest' and an 'individual's interests' it is necessary to have a working definition and develop some understanding of what these constructs are and how they develop. The Oxford Dictionary definition (2017) of interest is as follows:

> 1 [*mass noun*] the feeling of wanting to know or learn about something or someone: *she looked about her with interest* [*in singular*]: *he developed an interest in art.* The quality of exciting curiosity or holding the attention: *a tale full of interest.*
>
> [*count noun*] an activity or subject which one enjoys doing or studying: *their sole interests are soccer, drink, and cars.*
>
> 2 verb [*with object*] excite the curiosity or attention of (someone): *I thought the book might interest Eliot. (Oxford Dictionary Online, 2017)*

Others, such as that by Jenkins (2006), have worked to contextualise the definition of interest and describe how 'interest' may be manifest:

> . . . stretching the mind, fascination, intrigue and new insights into the physical world might be thought to be the central purpose of school science education. (Jenkins, 2006, p. 72)

Although these definitions are concise they have limited use for the purpose of this research as the terms they use to define interest are themselves open to interpretation and limitations with regards to measurement of interest or as a basis for developing ways in which to increase interest in lessons. These barriers may be reflected in the number of words used by some authors as alternatives to ‘interest’, including: attention; awareness; concentration; curiosity; emotion; attitude and motivation. All of these can be considered aspects of interest (Krapp and Prenzel, 2011) and are reflected in the everyday definition of the term above (Oxford Dictionary Online, 2017) although they are themselves distinct states of being. As a result it is necessary, in the context of this research, to understand the psychological aspect of ‘Interest’ and the attempts which have been made to define, sub-divide and model the development of this construct. The majority of the work in this area draws a distinction between *interest,* as a ‘transient affective state’*,* often referred to as *Situational Interest* and *interests,* or *Individual Interest,* as “self-sustaining motives that lead people to engage with certain objects, activities, or ideas for their own sake” (Silvia, 2001, p. 270). Generally, the researchers adopt the terms Situational Interest and Individual Interest to reduce the risk of confusion and in line with this practice this pair of terms will be used throughout this thesis. Specifically, Situational Interest will refer to the response that is generated as a result of the specific environment and context in which an experience or phenomenon is encountered; as such it is often short-lived. On the other hand, Individual Interests are specific predispositions of individuals and develop over longer periods of time (Krapp, Hidi and Renninger, 2015).

The role that interest has in learning is highlighted in *The Model of Domain Learning* (Alexander, 2004; Alexander, Kulikowich and Schulze, 1994) which describes stages in the development of expertise as having an evolving profile on a number of dimensions: Situational Interest; Individual Interest; strategies; domain knowledge; and topic knowledge. The model, as presented in Figure 2.1, describes Situational Interest as being high in the ‘Acclimation’ stage, which is the first stage of domain learning, and then decreasing as expertise is gained. Individual Interest, on the other hand, is described as starting at a very low level and increasing steadily as an individual becomes more proficient in a particular domain. Unlike other models, which will be discussed later, the Model of Domain Learning proposes that once an individual has increased competence in a domain it is not possible to increase their Situational Interest in the same domain. However, it does emphasise the important roles that both types of interest play in allowing an individual to master knowledge of particular domains. A drawback to this model is its restricted explanatory power as to how a teacher can support the development of interest beyond increasing a student's competency within a particular domain. It therefore has limited use for application within the classroom.

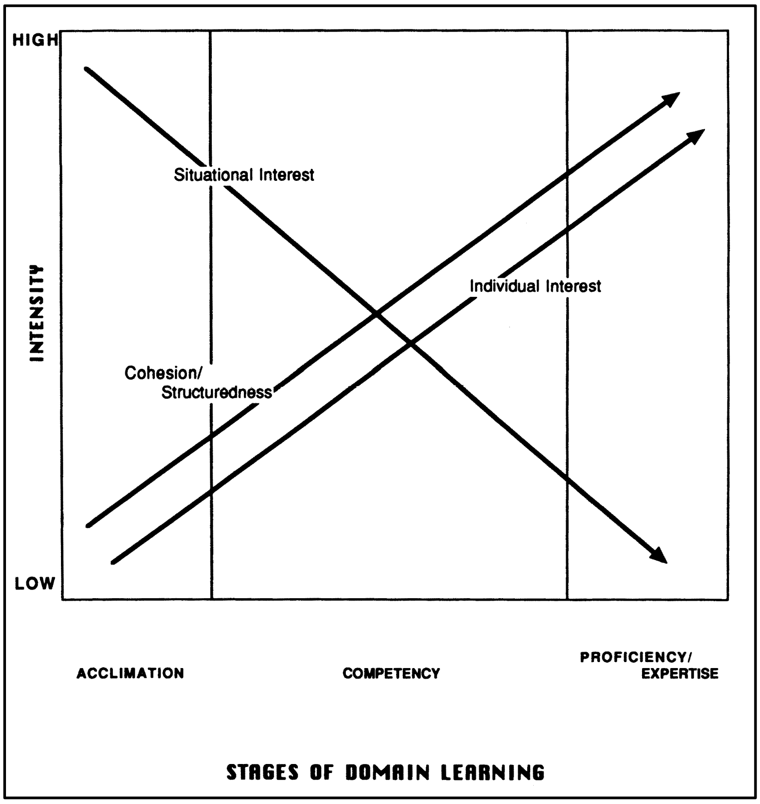


Figure 2.1 The relationship between subject-matter knowledge and interest at acclimation, competency, and proficiency stages of domain learning taken from Alexander, Kulikowich and Schulze (1994).

The concept of 'interest', which has been a focus of educational psychology research for many years, appears to be important for teacher and student motivation; a strong predictor of future choices and the quality of learning (Olsen, Prenzel and Martin, 2011). Interests, both Situational and Individual, are elusive and very personal states but research (e.g. Christidou, 2011; Hidi and Renninger, 2006) suggests that there are universal features which can trigger and maintain interests. It has been long acknowledged that interest plays a key role in motivating learners and in improving the quality of learning. As such, interest and interests have been the focus, or a component part, of a number of different theories which strive to understand learning better and/or what occurs when a person interacts with a specific content or artefact. One of the earliest works considering interest within the education setting was that of Johann Friedrich Herbart (1776-1841) who developed a general theory of education in which interest, as a contributor to learning and as an outcome of learning, played a pivotal role (Krapp and Prenzel, 2011). Herbart suggested that it was the role of the teacher to support the child in *reflecting* on their *engrossment* to promote the child's interest (Kim, 2015). These ideas were later developed by influential writers such as John Dewey (1859-1952) who defined genuine interest as "... the accompaniment of the identification, through action, of the self with some object or idea, because of the necessity of that object or idea for the maintenance of a self-initiated activity" (Dewey, 1913, p. 14). After these early publications, educational research moved away from studying the role of interest until it enjoyed a revival during the late 1970s as researchers found that the accepted theories did not "adequately account for all the important aspects of the traditional concept of interest" (Krapp, Hidi and Renninger, 2015, p. 4). One of the first theories to be presented as a result of this revival was the *Person-Object Theory of Interest* (Schiefele *et al.*, 1983).

Person-object theory of interest

Schiefele *et al.* (1983) set out to develop a general, rather than a specific, theory that was placed within "a pedagogical framework" (ibid, p.4) and as such paid particular attention to the developmental aspects of interest. The starting concept for their theory was based on the assumption that it is through analysing individuals' interactions with their physical and perceived psychological environments that we can understand human development and behaviour. They conceptualised interest as emerging "from the course of action [and being] the result of action" (ibid, p. 4) where actions can be both physical (external) and cognitive (internal). Schiefele *et al.* (1983) aligned the person-object theory of interest with general action theories, focusing in particular on the aspects of cognition, affect and value orientation:

> (a) Cognition; Action requires comprehension of situations and expectation, of oncoming events, of consequences, of measures, and demands a choice between alternatives;
>
> (b) Affect; Situations, expected or possible events appear to be touched with feelings; such qualities of experience of the action performance;
>
> (c) Value orientation; The decision to get involved with objects of interest and the choice of alternatives of action are based on the persons' value structures and take into account possible results and consequences.
> (Schiefele *et al.*, 1983, p. 9)

Based on the work by Schiefele *et al.* (1983), these three factors, became key components of the majority of subsequent theories of interest. In addition, Schiefele *et al.* (1983) assert that interest develops as a result of an individual's interaction with a particular object, event or idea due to the individual being changed by their interaction. It is suggested that as a result of interest and through this Person-Object interaction the individual will increase their understanding (cognition) and experience positive feelings that are a mix of 'effort' and 'comfort' (affect). Furthermore, the interaction is the result of self-intention and must have a purpose (value orientation). The level of expression of these three facets alters, along gradients, depending on the individual's level of interest in the object. Where there is "minimal interest" (Schiefele *et al.*, 1983, p. 22), the individual will have some cognitive engagement with the object, such as allowing the person to describe and distinguish the object of interest from other objects. In addition to this, the individual will initiate the interaction with the object and experience positive emotions from doing so. At the other end of the spectrum is what is described as "ideal interest" (Schiefele *et al.*, 1983, p. 22) where an individual can engage cognitively with the object in a much more complex manner, including criticality and metacognition with regards the specific object of interest. When this ideal interest is present the individual will experience complex positive emotions and feelings regarding the value of the object and interaction:

> This form *of* emotionality is integrated in other systems of the personality, e.g. in the sense of an increased reflexive pleasure capability.
>
> Likewise it is assumed that the person can reflexively judge the relevance that the object has for his personal identity as well as the meaning that the interest has for his personal value system. (Schiefele *et al.*, 1983, p. 23)

A theory of constructive capriciousness

Interest as an emotion was the starting point for Silvia (2001) when developing his theory of interest under the heading of 'Constructive Capriciousness' (see Figure 2.2). He theorises that Situational Interest is itself a discrete and basic emotion that can motivate an individual to engage in a specific behaviour and thus lead to developed Individual Interests.

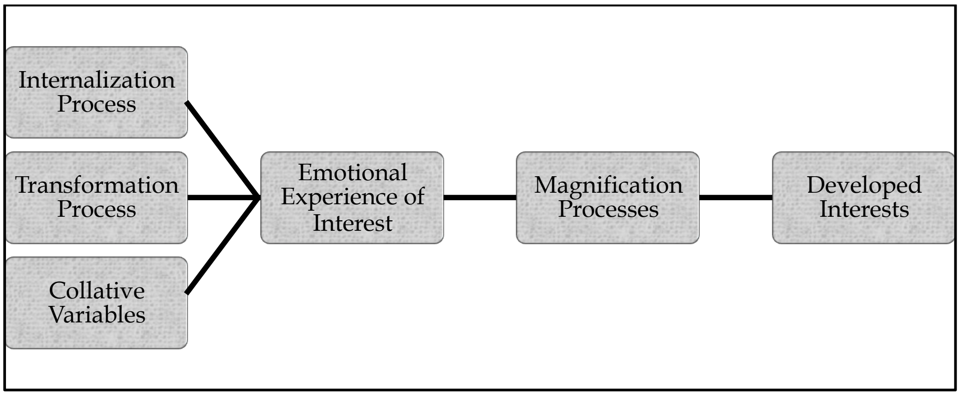


Figure 2.2 A theory of constructive capriciousness: “Pathways of Development of Interests” from Silvia (2001, p. 284).

Silvia (2001) proposes that interest, as an emotion, can be triggered by any of three different processes. First, the *internalization process* could trigger interest due to the individual adopting the accepted social norms about what is considered interesting or not. One view of this is that the interest will build competence and thus can be explained by the self-determination approach to internalisation (Deci, 2015; Deci and Ryan, 1985). Alternatively, the internalisation process can be approached from the *symbolic interactionism* school of thought which states that an individual may internalize, and therefore develop an interest, regarding activities which are valued by their social group (Shibutani, 1961).

The second possible trigger of interest is the *transformation process* where an interest develops around an activity that has not previously been linked to an existing source of interest due to a transformation in the reasoning for carrying out such an activity, for example, the realisation that learning to read music notation will support an existing interest of playing the guitar. Alternatively, this transformation could be the result of cognitive dissonance and therefore could be used to explain why people may become interested in tasks which are initially challenging or tedious in some way (Weick, 1964).

Third, if the object arouses curiosity in some way, for example, it is complex or novel, it can be said to possess *collative variables* as described by Berlyne (1978). Although curiosity is not the same as interest it is argued that the collative variables can affect the level of physiological arousal and therefore can encourage an individual to interact with the object in question and thus lead to the feeling of interest (Krapp, Hidi and Renninger, 2015). Experiencing the emotion of interest does not necessarily mean that the individual will go on to have developed Individual Interests in the area which triggered this response. In order for these Individual Interests to develop, the initial response must undergo one of the magnification processes. In its simplest form magnification can be the result of repeated interesting, as opposed to frustrating or upsetting, encounters with an object. An alternative magnification process could be that described by *script theory* (Tomkins, 1991), which states that interest is developed based on an internal script driven by knowledge. This therefore leads an individual to continue to engage in an activity as they have prior knowledge and an expectation that this involvement will be interesting. Finally, Prenzel (1992) describes the magnification process as pulling “the person from encounter to encounter with its ceaseless conflict” (Silvia, 2001, p. 285) and as such once the encounter ceases to be surprising, novel or uncertain, the activity ceases to be interesting. At present there is little empirical research to provide evidence as to the dominant magnification process.

Four-Phase model of interest

Hidi and Renninger’s (2006) Four-Phase model of interest is a well-developed model which builds upon the three aspects which Silvia (2001) described as being able to bring about the emotional experience of Situational Interest and the magnification processes required to develop Individual Interests. This model approaches the development of interest in a more concrete manner and as such it provides a framework for both the assessment of interest levels and possible ways of supporting its development. Thus it is particularly suited to the current study and so will be the central model of interest adopted for this work.

The model presents a linear description of the development of interest in four phases and states that continued support and engagement is needed for an individual to progress through each phase and to continue to develop breadth and depth of knowledge even when they have reached the final phase. Each of the phases is characterised by differing levels of effort, self-efficacy, goal setting and the ability to self-regulate behaviour. Phase one of Hidi and Renninger's (2006) model is *Triggered Situational Interest*, which is characterised by short term changes in affective and cognitive processing as a result of encountering a content which catches attention through presentation or by means of personal impact (Ainley, Hillman and Hidi, 2002). Once Situational Interest has been triggered an individual can move to phase two, *Maintained Situational Interest*, where attention becomes more focused and persists or recurs over a period of time. If interest continues to develop and become associated with positive feelings, stored value and stored knowledge it can be said to have evolved into *Emerging Individual Interest,* which is phase three. Here an individual starts actively to seek opportunities to re-engage with their emerging interest. The final phase of interest development is *Well-developed Individual Interest* which is "a relatively enduring predisposition to re-engage with particular classes of content over time" (Hidi and Renninger, 2006, p.115). If a person has a 'well-developed Individual Interest' for particular content they have greater stored knowledge, higher stored value and feel more positive about it compared to other content, including that for which they may have an emerging Individual Interest. A key factor of well-developed Individual Interest is that an individual repeatedly seeks to re-engage with content. This state does not just appear out of nowhere, but develops over time and is something that teachers should be able to stimulate and support. I have compiled Figure 2.3 around the Four-Phase model of interest described by Hidi and Renninger (2006); the central column represents each of the four phases of interest with the left-hand column indicating potential ways of supporting this interest phase and the right-hand column illustrating how this interest may be manifest in terms of potential outcomes.

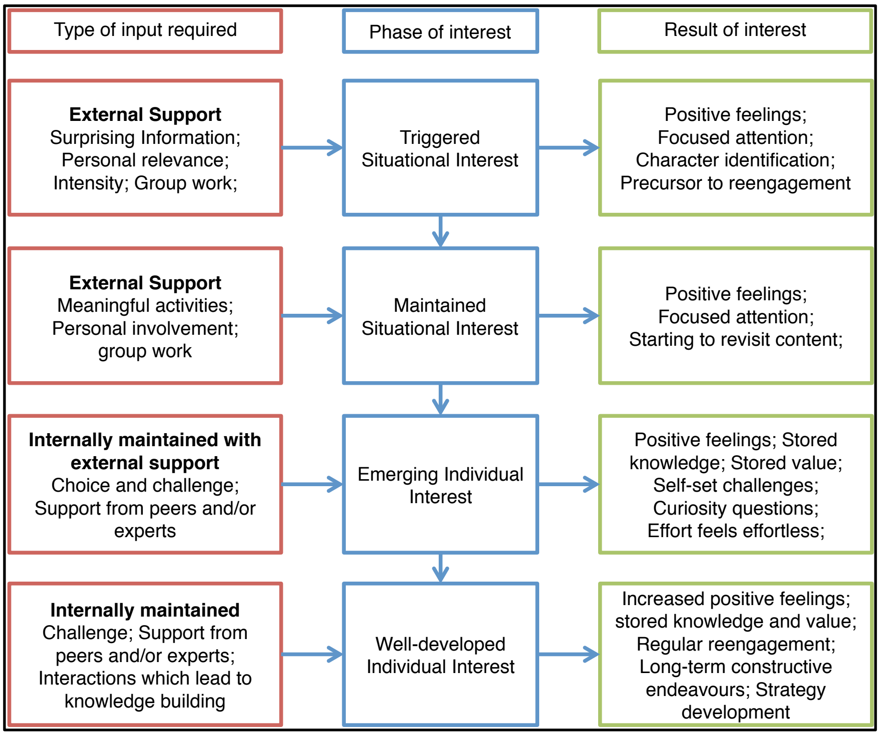


Figure 2.3 A representation of how components of pedagogy link to the development of interest based on the model by Hidi and Renninger (2006).

The Four-Phase model is distinct from the other models discussed above as it proposes that:

- All forms of interest are the result of interactions between an individual and an object (either physical or cognitive) / their environment;
- Both affect and knowledge inform the value placed on the object and both affective and cognitive factors inform each phase of interest development;
- It is possible for an individual to move both forwards and backwards through the linear stages of development and interest will be lost without support or further engagement;

- Situational Interest can be triggered even when a person has well-developed Individual Interest in the same domain;
- There is no concrete pairing of Individual Interest and expertise and thus it is possible for an individual to have expertise in an area but no well-developed Individual Interest;
- Competence, autonomy and social relatedness are not the only factors involved in interest development and that interest has a reciprocal relationship with these.

When developing the Four-Phase model of interest, Hidi and Renninger (2006) drew on a large body of research which investigated factors that may be employed to support the development of the interest phases. As much of this research does not distinguish clearly between 'Triggered Situational Interest' and 'Maintained Situational Interest', nor between 'Emerging Individual Interest' and 'Well-developed Individual Interest'. The remainder of this thesis will only refer to the two, broader, phases: Situational Interest and Individual Interest. Situational interest will refer to a student's interest within a science lesson or when engaged with a particular artefact or activity. Behaviours that demonstrate a student has Situational Interest include focused working on a piece of work, asking curiosity questions, displaying an emotional response to the activity. Individual interest will refer to a student's on-going engagement, or re-engagement, with a particular topic, artefact or science in general. This may be manifest in a number of ways, for example, through a student's desire to pursue a career in a scientific domain, instigating a discussion regarding a previously studied topic, or carrying out independent reading.

2.3 Value and purpose of science education

Research into 'interest' must focus on particular content and much of the research used to develop the Four-Phase model was based on individuals' interest in English texts (for example, Hidi and Baird, 1988; Wade, Buxton and Kerry, 1999). Other research (for example, Häussler and Hoffmann, 2000; Mitchell, 1993) has looked at interest in a variety of different contexts, with a range of different contents, including mathematics lessons, sports activities and science lessons. Furthermore, much of the previous research has focused on Situational Interest with regards to how an individual interacts with specific content and some, such as that by Mitchell (1993), looked more broadly at interest in a specific domain. This thesis will investigate student and teacher perceptions of what makes 14-16 year-old students interested in studying science in English secondary schools.

If an artefact is 'meaningful' to an individual, engagement with it is more likely to lead to Situational Interest which, in turn, could develop into Individual Interest. The importance of 'meaningfulness' should be considered at a number of levels: the specific activity, how it relates to the lesson or series or lessons and the more general value placed on learning science in schools. During their research, Osborne and Collins (2001) used focus groups to gain a deeper insight into students' views about the school curriculum. They found that the majority of the groups interviewed valued science as an important part of the curriculum, expressing its importance to society and its instrumental value. The only exception to this were those male students who were not planning further science study, which is partly explained by the fact that the most common reason given for the importance of science was for its value for future careers. It was clear that the students mainly valued science for instrumental reasons rather than because of any intrinsic interest. Although they were positive about the inclusion of science in their education it was found that "there were many aspects of school science that [the students] found uninteresting" (Osborne and Collins, 2001, p. 10). One explanation for this lack of interest in learning science is that students from developed countries, where there is low unemployment, are able to be more selective in their interests regarding school (Sjøberg and Schreiner, 2010).

Models of interest all suggest that an individual needs to feel that there is a purpose to the activity they are undertaking (Hidi and Renninger, 2006). This is not only related to the value that students place on learning science, but also to what students and teachers consider the purposes of learning science up to 16 years of age to be. Although there has been limited research in these specific areas a number of studies have provided some insight into the views of students regarding learning science (for review, see Jenkins, 2006).

To understand the purpose of science education one must first explore the overall purpose of compulsory education and how science education feeds into achieving this purpose. As Bell and Skiebe-Corrette (2016) argued:

> The question 'why study science' has been asked many times and will continue to be asked because without clarity of the purpose of education in general, and science education in particular, other questions such as 'what is to be included' and 'how it is to be taught and assessed' are without foundation. (Bell and Skiebe-Corrette, 2016, p. 477)

Since schooling is currently compulsory in England and Wales for students from aged 5 to 16 it is more productive for this study to restrict discussion of the purposes of education, and science education in particular, specifically to students between 14 and 16 years of age. One way to develop an understanding of the purpose of science education is to begin by understanding the purpose of the particular phase of education under investigation (Reiss, 2007). The version of the National Curriculum for England, which was in place for the students participating in this study, suggests that "The curriculum should enable all young people to become: *successful* *learners* who enjoy learning, make progress and achieve; *confident individuals* who are able to live safe, healthy and fulfilling lives and *responsible citizens* who make a positive contribution to society" (Qualification and Curriculum Authority, 2011). Those aims could be generalised and summarised as 'autonomy, well-being and justice' (Reiss, 2007, p.14) or, as the National Curriculum for England labelled them, 'successful learners, confident individuals and responsible citizens'. Although these aims seem appropriate, as they would enable individuals to fulfil their own potential as well as to contribute to society in a positive manner, it must be recognised that our understanding of what each of these aspirations looks like is socially constructed, culturally- and era-dependent. The intended aims of the current (2015) National Curriculum for England are:

> 3.1 The national curriculum provides pupils with an introduction to the essential knowledge that they need to be educated citizens. It introduces pupils to the best that has been thought and said; and helps engender an appreciation of human creativity and achievement.
>
> 3.2 The national curriculum is just one element in the education of every child. There is time and space in the school day and in each week, term and year to range beyond the national curriculum specifications. The national curriculum provides an outline of core knowledge around which teachers can develop exciting and stimulating lessons to promote the development of pupils' knowledge, understanding and skills as part of the wider school curriculum. (Department for Education, 2014, p. 5)

The aims for students can therefore be summarised as: 'development of knowledge, understanding and skills', similar to *successful learners* from the previous version; 'educated citizens', a continuation of the *responsible citizens* aim and, finally, for the students to have ‘an appreciation of human creativity and achievement’ which is the only element of the 2011 aim of creating *confident individuals* carried forward into 2015 version of the curriculum. Although the stated aims for the 2015 curriculum for England (Department for Education, 2014) are much more concise than in previous iterations of the document there are clear aims provided in each of the ‘Programmes of Study’: statutory requirements for all local-authority-maintained schools in England to follow. In recent years there has been much debate regarding the changing status and funding options for schools in England (for example, see Chapman and Salokangas, 2012; West and Bailey, 2013); however, all of the schools involved in this research were local-authority-maintained at the time of data collection and therefore had a requirement to deliver the National Curriculum. As such, there will be no further discussion regarding types of schools and their curriculum requirements.

The overarching aims of the National Curriculum lead into the aims of the programmes of study for all compulsory subjects. Since the National Curriculum was introduced in England, in 1988, it can no longer be argued that science education exists *solely* to train up future scientists (Osborne and Collins, 2001). Some individuals, regardless of age, might be able to give you a clear and concise purpose if they were to be asked why students learn science up to age 16; however, others, perhaps the majority of people, would not be able to give a definite answer and those who could might falter and develop their answer as they think about the question. What is perhaps more disconcerting is that it is not easy to find a concise and definitive statement of the aims of science education for students between the ages of 14 and 16 in the United Kingdom. The National Curriculum for England, both the 2007 and 2011 versions and therefore in place for the data collection phase of this research, stated “During the Key Stage, pupils should be taught the knowledge, skills and understanding of how science works through the study of organisms and health, chemical and material behaviour, energy, electricity and radiations, and the environment, Earth and universe" (Qualifications and Curriculum Authority, 2007, p. 224). In the Association for Science Education's Guide to Secondary Science Education, Harlen (2011) suggests that the purpose of science education should be to allow all students to develop "a grasp of the big ideas that enable active participation in decisions involving science and technology, a basic understanding of what science is, how it works and what are its strengths and limitations, and the ability to continue learning" (Harlen, 2011, p. 4). To add further to the picture the examination boards state the aims of their particular specifications; for example, Edexcel stated:

> This GCSE in Science encourages students to be inspired, motivated and challenged by following a broad, coherent, practical, satisfying and worthwhile course of study. It provides insight into and experience of how science works, stimulating students' curiosity and encouraging them to engage with science in their everyday lives and to make informed choices about further study and career choices. (Edexcel, 2011)

It is of great concern, however, that in Osborne and Collins' study (2001) the overwhelming impression was that students view school science as a collection of facts to be learnt and regurgitated on demand which suggests that these students had never engaged with, nor considered, the wider aims.

The final question which must be asked is how we decide which aims are more important for which students and whether the delivery of the aims should be differentiated in some way. When considering examination specifications and the students who are entered for each qualification, it would be reasonable to surmise that some hold the view that lower-ability students need to develop more skills and less scientific knowledge as these students are often entered for applied science qualifications or vocational courses. Teachers have to judge this for each of their classes and each student within each class. In addition to ability, there may be a whole range of considerations which may important here.

Overarching objectives for science lessons can be broken down to a number of possible groupings: interesting; authentic; allows development; allows autonomy; informative; participatory. Each of these groups needs careful consideration as to its meaning and expression in the science classroom, furthermore, each may be strongly related to one or more of the other objectives, although to date very little research has been done into how they are interlinked (Mitchell, 1993). Once working definitions, and an understanding of the relationships between the constructs, have been developed it is necessary to examine how these constructs can be incorporated into lessons in a way which allows students to access and achieve the objectives.

Since the *Beyond 2000* report (Millar and Osborne, 1998) there has been much discussion about the need to develop scientifically literate students, and calls for this to be a goal for school science education for students between 14 and 16 years of age. Since this time 'scientific literacy' has been defined in a number of ways although all definitions seem to cover the following aims: 1) developing knowledge and understanding of some science concepts; 2) an understanding of the processes involved in the conduct of, and reasoning about, science; 3) an understanding that science endeavours are social human activities which involve cultural contexts and value judgements (Ratcliffe, 1998). There is strong support for the first of these aims and there also appears to be a significant amount of support from many of the stakeholders in science education for the teaching about the nature of science

(Osborne *et al.*, 2001). However, there is little evidence about the value teachers and students place on the third of these aims.

More recent UK studies have found that a great majority of students feel that it is important that everyone continues to learn science up to the age of 16 (Butt *et al.*, 2010; NFER, 2011). The main reasons given for the importance of an education in science were instrumental, in that it is seen to help students with future career or university prospects, even if they do not pursue a science-based career. Interestingly, students also commented on the benefits of developing analytical and research skills (NFER, 2011). Although these studies have asked students about the relative importance of studying science in school, research which assesses students' understandings of the purpose of school science is scarce.

An important aim of science education, in fact all education, is to develop a wide range of skills. However, there is wide debate about which subjects should develop which skills. Anecdotal evidence suggests that some science teachers believe that literacy and numeracy are solely the responsibility of English and Mathematics lessons respectively. In recent years there has been more focus in England on generic skills which should be delivered across the school subjects, referred to as 'Key skills' or 'personal learning and thinking skills' which cover literacy, numeracy, critical thinking, refection and information technology skills. The argument for including these generic skills is, in part, to prepare students for the workplace. However, there is a lack of clear definitions and issues with developing these skills in students may arise if teachers have not been trained on the most effective teaching methods for them (Leggett *et al.*, 2004).

This issue can also be approached from the direction of relevance or context; the importance of learning science to the individual and how it will affect them. Millar and Osborne (2006) give four arguments for the development of the public understanding of science: reliable and useful knowledge; economic; democratic; and cultural. Although there are still extensive discussions as to which of these predominates, it may be that all play a role. In a school context, Van Aalsvoort (2004a), after extensively reviewing the literature, categorises four types of relevance important in chemistry education, although they can be applied to science education as a whole:

a. personal relevance — chemical education ought to make connections to pupils' lives;
b. professional relevance — chemical education ought to offer pupils a picture of possible professions;
c. social relevance — chemical education ought to clarify chemistry's purpose in human and social issues; and
d. personal/social relevance — chemical education ought to help pupils to develop into responsible citizens. (Van Aalsvoort, 2004a, p. 1635)

The importance of students being able to see the relevance of what they are studying is perhaps demonstrated by the responses to many student attitude surveys (for review, see Jenkins, 2006) where more interest is reported in biological sciences, which can be argued to have applications which are more obvious to students (Osborne and Collins, 2001). The importance which students place on relevance is evident to every teacher; as the first question often asked by students who are lacking in interest is "why are we doing this?". This importance should not be under-estimated as "school science education can only be successful when pupils believe that the science they are being taught is of personal worth to themselves" (Reiss, 2000, p. 156).

One complication in this discussion is, as so often is the case, the language which is used to communicate the concept. Some talk about the 'purpose' of science education, others focus on 'aims', ‘targets’ or ‘objectives’. When trying to assess the expectations of teachers and students it is important to ensure, so far as possible, that all are using a common language with a shared understanding. I will use *purpose* to refer to the overall intentions of science education (for example, to introduce students to the knowledge that has been gained by empirical study of the physical world); *aims* when discussing what needs to be achieved as part of the science curriculum at particular stages (for example, to enable student to understand how characteristics are inherited) and *objectives* at a more fine-grained level, when examining what is to be learnt within a particular topic (for example, to be able to describe the behaviour of chromosomes in meiosis) The term ‘target’ is usually used in school to refer to a particular grade a student is striving to achieve; as such, this is less relevant in the context of this research where the intent is to investigate the importance of communication of the purpose, aims and objectives involved in students’ learning. Achievement of a target grade may be a way of demonstrating that the pupil has fulfilled the objectives and purposes of science education. However, that assumes we have the ideal situation in which the assessment and grading match closely with the aims and objectives of science education.

Teachers’ views of the purpose of science education

A pivotal aim of science education is the development of students’ interest in the subject; however, interest is also vital in supporting students to achieve the other aims of science education. Indeed, for science education to be effective there must be an agreement as to the aims and objectives of science lessons between the parties involved; therefore, effective communication between teachers and students, as well as others involved in science education, is crucial. There is surprisingly little published research which presents what teachers see as the primary purpose of science education. However, teachers’ expectations of the purpose of science education can, to some extent, be inferred from the responses they give to related questions. Osborne and Collins (2000) found that the teachers in their study believed that the Science National Curriculum for England and Wales was too academic in its presentation of science and did not include enough material which held relevance and interest for the students. The reader is left with the impression that the teachers would prefer a curriculum which aims to prepare students to become scientifically literate citizens. However, there is the suggestion that the teachers do not have a collective and fixed view about what the most important aim is since a recent GCSE course, which aimed to promote scientific literacy was only adopted by around 20% of schools, despite it having no negative impact on progress to studying science at post-16 level (Homer and Ryder, 2015).

The Wellcome Trust Monitor (2010) asked adults as well as students about their views of science education and found that substantially more adults than students felt that it is very important for science education to be compulsory up to age 16. I can find no data which assesses teachers' views on the importance of learning school science.

How does a teacher decide which of the myriad of stated aims they are trying to achieve? A discussion of how teachers may achieve and communicate the aims of their science teaching follows, after more detailed examination of a number of the potential aims. However, a vital question to be asked is: 'Does the multiplicity of these aims overwhelm and result in the teacher retreating to a 'safer' goal – to achieve the highest grades for the qualifications possible for each student?' It could be argued that this is not a problem – if the assessment criteria for each qualification provide a valid measure of the aims laid down by the examination board. However, there have been many criticisms of assessment tools in recent years, especially those which aim to measure scientific literacy (Dohn, 2007). On an individual level, and on a day-to-day basis, discussions take place in schools about targets, be they performance management targets for teachers or grade targets for students. Such grade targets constitute concrete, objective and measurable goals which students work towards over one or two years. In the pursuit of these targets the larger purpose and aims of science education are all too often forgotten. There are strong arguments that this is especially true when the assessment is heavily focused on examinable content (Watts and McGrath, 1998). Similar themes, regarding the emphasis place on 'teaching to the examination', have been reported regardless of the methods used to collect data; questionnaires, interviews and observations invariably highlight the same issues. For example, when students were asked whether or not they felt their science lessons were 'exam-led', 85% responded 'yes' (Planet Science, Institute of Education and Science Museum, 2003). This strongly indicates that they believed that the main driver for their teaching was the assessment procedure. It is also well documented that teachers feel there is a tension between teaching content in the ways they would like to and what must be done to support students to achieve the highest grades possible (Osborne and Collins, 2000).

With regards to purpose:

> It was no longer possible to offer experiences to pupils in science which were specifically designed 'for their enjoyment, their understanding of certain concepts and science at large in the world' (T5/141); instead, it was said, 'you're just trying to get through the syllabus' (T5/141). (Osborne and Collins, 2000, p. 65)

Sharp *et al.* (1996) asked heads of science to rate factors on the extent to which they influence students' decisions on studying science post-16. The heads of science ranked the factors in the following order: career aspirations; students' liking for physics; teachers' enthusiasm for physics; students' prior achievement. This finding shows that teachers believe that it is for the purpose of a career, over interest or aptitude, that students will continue to study science beyond GCSE level. This further supports the idea that the purpose of studying science is seen to be in order to gain a qualification to improve career prospects. It can only be hoped that these teachers see the goals of generating students' interest as an aspect of their role in supporting the student of science. This interest would increase the chances of a student choosing to continue to study or work in a scientific domain.

2.4 Individual differences and interest in science

Although one of the aims of interest research is to develop a universal model of interest development, it must also be acknowledged that individual differences will have a strong impact on a student's interest development in a particular domain. It is therefore important to understand that the goal of this study is to consider how best to afford an individual the opportunity to develop interest, rather than to make all students unerringly interested in science.

Gender and interest in science

Gender has been shown to have a strong impact on Situational Interest (Ainley, Hillman and Hidi, 2002), although this particular finding was based on student responses to a range of literary texts, rather than scientific topics. When looking at gender differences in attitudes towards learning science the general trend is that boys are more interested in science than girls. Warrington and Younger (2000) surveyed 15- and 16 year-old students in 20 English comprehensive schools and found that only 6% of girls said that science was their favourite subject, compared to 37% of boys. This was a large study, focused on a range of gender differences and the gender gap in achievement in achievement in examinations at 16+. Given the size of the sample and the levels of interest and enjoyment of science reported by other studies (for example, Archer *et al.*, 2017; Murphy and Whitelegg, 2006), these findings can be considered to have both internal and concurrent reliability. However, researchers have struggled to understand the underlying cause for this pervasive trend. One explanation which has been offered for a considerable length of time is that there is a ‘masculine’ view of science and scientists and that students are sensitive to this as they develop (Kelly, 1985). Unfortunately, this view has not changed significantly and during their three-year study of English schools Warrington and Younger (2000) themselves found that some subjects were considered by students to be either ‘male’ or ‘female’. Furthermore, the perceptions students held of different careers were also highly gendered. Gender stereotyping has been demonstrated to reduce female students’ interest in a computer science task even when the students reported that they did not believe the stereotype to be true (Smith, Sansone and White, 2007). However, Breakwell, Vignoles and Robertson (2003) found that students, both male and female aged 11 to 16, rated themselves and others more highly on ‘feminine’ and ‘non-gender specific’ traits than on ‘masculine’ traits. Furthermore, the gender differences in liking and interest in science have been found to be more dramatic in older students; for example, Reid and Skryabina (2002) found that there was a greater gender gap in students aged 13-14 than in the 10-12 year-old students surveyed with boys reporting a greater interest in science in both groups. It is likely that these differences in interest levels between male and female students contribute to explaining why significantly more male students take science subjects at 16+, once they are no longer compulsory (Bennett *et al.*, 2013).

An enduring theme throughout research into the views of girls and boys with regards to learning science is girls’ preference for biological topics and typical dislike of physics topics (for examples see Angell *et al.*, 2004; Planet Science, Institute of Education and

Science Museum, 2003). Female students, more so than their male peers, also want to understand the everyday relevance of the topics covered in their science lessons, placing greater value on science as it relates to themselves (Angell *et al.*, 2004; Osborne and Collins, 2001).

The Relevance Of Science Education (ROSE) project (Sjøberg and Schreiner, 2010) found significant gender differences in the contexts for learning science across all 33 countries which provided data. It was found that on average male (and not female) students were interested in 'technical, mechanical, electrical, spectacular, violent, explosive' contexts and the female (and not male) students were interested in contexts based upon 'health and medicine, beauty and the human body, ethics, aesthetics, wonder, speculation (and the paranormal)' (Sjøberg and Schreiner, 2010). Similarly, in a review of empirical research, Murphy and Whitelegg (2006) concluded that in general social context of knowledge and knowledge construction are important factors in increasing the interest of female students in physics. Therefore, the influence that context has on interest level in male and female students could explain at least some of the differences reported between topics of interest to each gender.

The concept of 'self-efficacy', developed by Bandura, refers to:

> . . . people's beliefs about their capabilities to produce designated levels of performance that exercise influence over events that affect their lives. Self-efficacy beliefs determine how people feel, think, motivate themselves and behave. Such beliefs produce these diverse effects through four major processes. They include cognitive, motivational, affective and selection processes. (Bandura, 1994, p. 2)

It has long been accepted that the role of cognitive and affective factors in determining a person's level of self-efficacy within a particular domain means that this is closely related to their interest level within the same domain (Bandura and Schunk, 1981; Hattie and Yates, 2013). There are a number of factors which can influence levels of self-efficacy, ranging from experiences unique to an individual to society's views of different groups of students, be they male, female, having special educational needs, high or low ability. A number of studies have shown that, with regards to scientific endeavours, female students have lower self-efficacy than male students and that female students often report a more pronounced decline in their perception of their ability over time than male students (Wang and Degol, 2013; Wender, 2004). However, Uitto (2014) found that there was no gender difference in self-efficacy with regards specifically to biology and that the commonly reported finding that male students have higher self-efficacy than female students only manifests when physics and chemistry are included alongside biology.

Furthermore, it has been reported that for both male and female students it is their level of interest in a scientific domain and their level of self-efficacy which are the strongest determinants of their intention to pursue a career in that domain (Uitto, 2014). However, as is the case with all human behaviour, a large number of factors influence students' aspirations and Archer *et al.* (2013) found that parental attitudes towards science also have a large effect on student career intentions.

Ability level and interest in science

There is relatively little research into the role that academic ability may play with regards to students' interest or motivation in science classrooms and even less research where the focus is on students considered to be of lower academic ability than their peers. As such, one must draw on evidence from older research which, although not contemporary, is still relevant. In one such study, Anderman and Young (1994) used a survey methodology to investigate relationships between students' beliefs about the focus of instruction and their own abilities both within school and, more specifically, within science lessons. As part of the study, the teachers developed the following definition of students with academic difficulties and then identified which students they felt fitted into this group:

> Teachers brainstormed about the typical characteristics of students who experience academic difficulties. They arrived at the following definition, which was used to identify the students in the second group: "Identify students whom you feel are in danger of experiencing 'significant problems in school' based on the students' academic performance or the teachers' observations of the students in school." Teachers were then asked to identify any students they taught during the day to whom they thought this definition applied. (Anderman and Young, 1994, p. 818)

Anderman and Young (1994) found that the students identified as having academic difficulties had lower scores than other students on their end-of-year science assessments and scored lower on the questionnaire scales for self-efficacy, expectations of their future performance, self-concept of ability and the extent to which they valued science.

Anderman and Young (1994) also investigated students' motivation, and how teachers influenced this, using the social-cognitive approach of Goal Theory (for example, Ames and Archer, 1988). They found that students identified by their teachers as experiencing academic difficulties were more likely than other students to see school as being ability-focused (learning as a means of demonstrating ability and trying to outperform others; also referred to as *performance goals*) and less likely than other students to see school as being learning-focused (learning for its own sake; *mastery goals*). These differences were repeated when looking specifically at science and so they concluded that “students who adopt goals aimed at demonstrating their ability or outperforming others may be unlikely to want to master and deeply understand their science work simultaneously” (Anderman and Young, 1994, p. 826). Similar findings were presented by Debacker and Nelson (2000) who found that lower achieving students had lower learning goal scores than higher achieving students. However, the issue of how a student’s ability impacts on their progress in, and attitudes towards, school are muddied by the common practice of placing students in classes based on their prior attainment: ability setting.

2.5 The impact of culture on interest

Ability grouping and interest in science

Grouping students across all school subjects in any manner, be it by ability or form group, as is common practice when students enter school at age 11, will, by the nature of physical proximity, lead to the development of student peer groups (Segal, 1974). These peer groups, which may be well established by the start of the GCSE course at 14 years of age, have been shown to have some influence on student interest and engagement. In a longitudinal study, Kindermann (2007) found that peer group influence slightly affected student engagement over the school year and that “students who initially shared networks with highly engaged peers remained engaged or even increased, whereas students with less engaged groups showed declines” (Kindermann, 2007, p. 1197). More recently, Robnett and Leaper (2013) concluded that context is important as the support a student received from their peers regarding science subjects influenced their likelihood of pursuing a science-based career, whereas peer support regarding English was not found to have such influence. In addition, Vogl and Preckel (2014) reported that students placed in a ‘special class for the gifted’ had increased self-concept and better relationships with their teachers than their counterparts taught in a ‘regular’ class. This field study was conducted over two years with 198 students in a matched-pairs design, lending robustness to the findings.

Societal influence on interest in science

In recent years there has been an increasing amount of research into the differences in the numbers of students from different ethnic groups continuing to study science post-16 (for example, Bennett *et al.,* 2013; Gill and Bell, 2013). There is little evidence, however, to suggest that these differences are the result of differing interest levels. There appears to be no empirical research to date to suggest that students of different ethnic backgrounds in English schools have different levels of interest in studying science. In fact, there is strong evidence supporting the idea that in general there are no differences in what areas of science interest students from different countries. Hagay *et al.* (2013) surveyed students from 600 schools across four countries, including England, and found that students were interested in similar types of science questions. However, they did find that religious affiliation, national affiliation and gender had influence within the samples from each country. It could, therefore, be possible that specific differences in culture impact student interest levels. Given the importance of 'meaningfulness' in triggering interest, discussed above, the value placed on science within a particular culture could shape an individual's level of interest. In addition, the culture within a school or particular region could also serve to support the development of a student's interest, the value they place on science (Archer *et al*., 2013), the interest displayed by others (Rodd, Reiss and Mujtaba, 2013) and the external support provided (Hidi and Renninger, 2006).

2.6 Supporting the development of interest in studying science

In his review, Jenkins (2006) presents a number of studies into students' views "about their school science education and matters related thereto" (Jenkins, 2006, p. 4), which includes studies on students' interest in learning science. It was noted, however, that "in investigating 'student interest', researchers have usually treated such interest as a personal attribute of the student rather than as an outcome of science education" (Jenkins, 2006, p. 2). When considered with the models of interest in mind, this may lead to misinterpretation of the data and reduce the potential for impacting on the science curriculum and pedagogy. Since all of the models described above are based on the idea that interest emerges from the interaction a person has with an object, activity or idea, it is reasonable to assume that a student's experience of learning science in school has the potential to impact heavily their level of interest in learning science, rather than 'interest in learning science' being an innate personality trait.

There is a wealth of research, from a range of subject areas (for example, Ainley, Hillman and Hidi, 2002; Christidou, 2011; Hidi and Renninger, 2006), both with regards to the factors which will support the development of each stage of interest and the resulting behaviours and feelings of achieving either Situational or Individual Interest. Since this thesis is grounded in the context of science education in English secondary schools, between the ages of 14 and 16, the following discussion will focus on issues pertaining to interest development in this specific context. A limited number of studies have been conducted in schools in England and the interest levels of students in these schools. Therefore, this literature will, by necessity, draw upon research from a number of different countries. Although such research will have been conducted in different contexts to the current study, it has been shown that overall patterns of interest are similar across different countries (Hagay *et al.*, 2013) and therefore these studies are still relevant.

Relating the outcomes of research to classroom practice

Previous research (for example, Archer *et al.*, 2013) has suggested that school student interest in learning science reduces over time. However, there is conflicting evidence as to when students' interest in science wains as they progress through school. It is generally accepted that younger (8-10 year-old) students' interest and liking for science is high and drops more or less steadily as they enter secondary school and progress through the rest of their compulsory schooling. There is debate as to precisely when this fall off in interest occurs with some studies (Murphy and Beggs, 2003; Pell and Jarvis, 2001) reporting a measurable decline towards the end of primary school (11 years of age) but others (Archer *et al.*, 2013; Reid and Skryabina, 2002) indicating that it does not commence until after 14 years of age (i.e. well into secondary school). In any event, these reports imply that there is a need to promote student re-engagement and increase students' interest at GCSE level (14-16 years of age).

Students are aware of how teachers can influence their learning and interest in science. Similar issues are often raised in student responses regarding teaching quality, specifically teachers' enthusiasm and qualifications, better teaching methods and consistency of teaching (for example, Murray and Reiss, 2005). Students can also be insightful regarding teachers' areas of interest and preferences for teaching in different domains (for example, Reiss, 2000) and therefore teachers need to be aware of the unintentional messages they are communicating to students. As Yang (2016) reports, students are more likely to refer to their teachers than to any other significant adults when discussing those who have influenced the development of their interest in science. Specifically, the students in Yang's study spoke of the importance of the inter-personal relationships they had with influential teachers in terms of both increasing and decreasing interest. The following quotations, taken from Yang (2016), illustrate examples of both positive and negative student-teacher relationships:

> Interviewer: Is there anything in your life that has affected your interest in science? Andrea: That one genetics class I took in high school … I really liked the teacher ... He was really interested in what we were doing, in our success and failure with fruit flies … He always asked us about them. He helped us with them. If we were frustrated, he reassured us. (Yang, 2016, p. 24)

> Interviewer: Is there any person in your life who has affected your interest in science negatively? Edna: Just teachers. The way they teach it … Basically it's like they are told what they have to teach for this class, and they go over that. There is no like, "Well, I know this is interesting," like interesting facts at the beginning of the class, like "Do you know what's happening outside?" It's just like, "We are here. We are going to do our job, and we are going home." (Yang, 2016, p. 25)

Situational Interest and science education

Situational Interest can be triggered by a wide range of factors including personal relevance, surprising information, creative presentation and meaningful activities (see Figure 2.3 above). The power of science includes its ability to lift us out of the everyday, rather than just explain the mundane. Therefore, science lessons, by their very nature, include surprising information; however, a balance must be obtained as although surprising information may increase student interest in a lesson, it has been found that 'seductive details' actually reduce recall of main scientific ideas when included in text-based learning activities (Alexander, Kulikowich and Schulze, 1994; Harp and Mayer, 1998). Through a number of experiments, Harp and Mayer (1998) concluded that this effect was not the result of distraction; rather, these seductive details shaped the schemas individuals used to organise the information at a cognitive level, thus inhibiting an individual's ability to recall key information or transfer problem-solving skills.

Creative presentation of content, by both teacher and student, has clear connections to developing and allowing expression of students' interest. Investigative work and active learning techniques are aspects of creative presentation. When NFER (2011) asked student focus groups why they were interested in science lessons, the majority of responses related to teaching methods, such as those that encompassed varied, interactive and practical activities and differing teaching approaches. The Wellcome Trust Monitor (Butt *et al.*, 2010) found similar results for factors which students said helped to engage them as well as factors which reduce students' willingness to study science. The use of teaching activities which allow students to model abstract concepts in science is one way of introducing creative presentation of the material. Models can fail to engage students or may be brought to life through the use of drama (Darlington, 2011) or artistic endeavour, such as creating objects in plasticine, in order to support students' in developing an understanding of phenomena they cannot see (Renninger, 2000). Although the majority of studies report student enjoyment of active learning (e.g. Planet Science, Institute of Education and Science Museum, 2003), there are studies which have found that some students prefer teacher-led delivery where the teacher presents information or solves problems on the board (Lavonen and Laaksonen, 2009).

As mentioned above, context has been shown to have a significant influence on interest and in some cases to be more important to the development of interest than the subject content or activities in a lesson (Häussler and Hoffmann, 2000; Jenkins and Pell, 2006). Although Mitchell (1993), who investigated what triggered Situational

Interest in mathematics classrooms, found that meaningfulness, which could be linked to context, did not appear to be linked to cognitive development in mathematics, his findings did show that meaningfulness played a significant role in the triggering of interest. A precursor to students becoming personally involved in an activity is their identifying that a task is meaningful or has personal relevance; this is key if a student is to develop Situational Interest. Project work is a useful tool to encourage students to become personally involved in their own learning and it therefore supports the development of Situational Interest (Niemiec and Ryan, 2009). It may be that project work provides a clear scaffold which supports students in moving towards a more autonomous mode of learning where they feel they have more control, an important factor in supporting the development of Individual Interest (Deci, 2015).

Individual Interest and science education

Individual Interest is characterised by positive feelings towards the content and its value as well as stored knowledge. Although, for the most part, it is self-generated (develops from the individual choosing to continue to re-engage with the object of interest) and the student will independently seek opportunities for re-engagement with the content, it is still possible to provide external support for its development (Hidi and Renninger, 2006). One key characteristic of Individual Interest is that a student will generate their own curiosity questions (Lipstein and Renninger, 2006). Therefore, it is encouraging that students feel that some GCSE science specifications do encourage curiosity. The study by Planet Science, Institute of Education and Science Museum (2003), for example, asked students 'Does GCSE science encourage curiosity?'. The majority of students, 58%, answered 'Yes', although there was no option for 'sometimes'. When asked to select the adjective they felt best described GSCE science, the most common terms ticked were 'interesting', 'useful', 'relevant' and 'thought provoking'. Comparing the answers to a number of the questions shows the study to be internally reliable; for example, those who said it did not encourage 'curiosity' most commonly selected 'boring' as the best adjective to describe GCSE science.

When describing Individual Interest, Hidi and Renninger (2006) suggest a number of factors which can support its development. There is obviously a clear link between how science is taught and whether or not students develop an interest in science. Kinchin (2004), for example, found that the vast majority of the students in his study stated that they would prefer to learn in a constructivist classroom rather than in an objectivist one and the most frequent reason given for this was that it would be more interesting. This study was carried out using concept cartoons of classroom settings that allowed students to discuss the images without having to understand the language used by researchers such as 'constructivist'. However, students may not have fully understood the different teaching styles and Kinchin himself reported that "some responses simply appear to reproduce the text uttered by the characters in the concept cartoons in a way that reflects the philosophy depicted in the objectivist class" (2004, p. 308). Furthermore, it was not only the text that differed between the cartoons; the 'objectivist' cartoon showed a student sitting with a book and the 'constructivist' cartoon showed a computer. These differences in the images could have had a greater impact on student responses than the text describing the roles of the student and teacher.

One of the factors identified by the Four-Phase model is 'challenge': this is a difficult phenomenon to define and one that is even trickier to introduce at the correct level for all students in a classroom. Research findings regarding the importance of students being presented with challenge report mixed messages. Surveys of student views have shown that students report more enjoyment of a particular domain of science when they find it easy, but also that despite finding something difficult they can still enjoy it (Jenkins, 2006). There has been a significant amount of research into the concept of challenge within both the fields of educational psychology and personality psychology. Deci (2015) asserts that in order to support interest in an activity, the said activity must present *optimal challenge*, slightly beyond an individual's current knowledge or capabilities and "not fully mastered but … not so discrepant as to be frustrating" (Deci, 2015, p. 51). If this is interpreted within a social learning context, the challenge level and activity described by Deci (2015) is placed within Vygotsky's *Zone of Proximal Development* which reflects the levels of development possible when an individual is performing tasks in collaboration with a more experienced other (Vygotsky and Rieber, 1988).

When considering how students can be supported in their development it is important to bear in mind that:

> The idea of a zone of proximal development is meant to direct attention to the idea that instruction/teaching (*obuchenie*) should be focused on maturing psychological functions, rather than already existing functions, that are relevant for the general intellectual development to the next age period. (Chaiklin, 2003, p. 57)

Therefore, introducing challenge is not solely related to establishing what students currently know and what they need to know; rather, age-related stages of cognitive development must be acknowledged along with the skills and understanding students are required to master. There are a number of pedagogical techniques which can be used to tailor the level of challenge experienced to students' needs, one of which is modelling thought patterns and complex ideas. This has been shown to be an important and successful way of supporting students to develop their understanding of science topics through providing guidance and scaffolding to shape their thinking (Renninger, 2000).

The impact of differing levels of challenge may be personal to each individual student. It is often argued that interest is key to an individual's development with regard to subject knowledge and skills; however, some students' interest in physics courses is not in fact due to an interest in physics per se but is primarily driven by the level which they achieve on assessment tasks (Häussler and Hoffmann, 2000).

Students have often expressed the opinion that the transition point where science becomes more difficult occurs during or just after Year 9, at age 14 (for example, see Osborne and Collins, 2001). As a result of this, many students may already feel that science has become too challenging for them before they embark on their GCSE studies and subsequently lack interest at the start of this course. This is further supported by Reid and Skryabina (2002) who surveyed almost 400 students, aged 13 to 14, and found a strong positive correlation between their interest in science and their self-efficacy.

As students progress from Situational to Individual Interest, they increase their level of stored knowledge (Hidi and Renninger, 2006); furthermore, Schraw, Flowerday and Lehman (2001) have suggested that prior knowledge is an important factor which influences student interest. In particular, it has been found that, in mature students, increased levels of domain knowledge significantly correlate with increased interest (Alexander, Kulikowich and Schulze, 1994). There is currently little research into the relationship between knowledge and interest in school-age students and even less longitudinal research into how these factors interact over time for younger students. In addition, research surrounding self-determination theory concludes that competence, autonomy and relatedness are basic requirements for students to internalise external motivators and thus develop Individual Interest (Deci, 2015). Similarly, how competent an individual perceives themselves to be in an area is positively correlated with their interest level in that area (Ryan and Grolnick, 1986).

Initially, it would appear that understanding the role of 'prior knowledge' cannot contribute significantly to helping teachers to support the development of interest as a student's current teacher will probably have had little influence or control over the prior knowledge that the student has brought with them to the classroom. However, teachers do have the opportunity to support students in making links between topics previously and currently studied and therefore can 'unlock' a student's prior knowledge by making them aware that they do know something. This is particularly relevant given the spiral nature of the National Curriculum for England. However, there is still a challenge in a secondary school setting where it is not uncommon for students to have a different teacher for each academic year, between 11 and 14 years of age, and for another teacher to teach their Key Stage 4 course. Prior knowledge can also have an impact in the form of Individual Interest, and therefore a student's expectations as to how interested they are likely to be in a particular situation (Ainley, Hillman and Hidi, 2002).

The level of choice and control an individual has over both the context and content of their learning have been shown to have a significant impact on their reported levels of interest. An explanation for this effect is that by offering the students choice they are more likely to integrate the regulation of external motivators which, in turn, may lead to the development of Individual Interest (Chirkov and Ryan, 2001; Deci, 2015). There are a number of instructional activities that students perceive to be 'autonomy supportive' and the exact list varies between studies. In a teacher-student laboratory study, Reeve and Jang (2006) found eight behaviours correlated positively with students' experiences of autonomy:

> ... including listening, creating time for independent work, giving the student opportunities to talk, praising signs of improvement and mastery, encouraging the student's effort, offering progress-enabling hints when the student seemed stuck, being responsive to the student's questions and comments, and acknowledging the student's perspective and experiences. (Reeve and Jang, 2006, p. 215)

It is important to note this list includes activities which praise the students as well as those instructional techniques which provide support and choice for the student within the task. These two aspects were summarised by Niemiec and Ryan (2009):

> Students' autonomy can be supported by teachers' minimizing the salience of evaluative pressure and any sense of coercion in the classroom, as well as by maximizing students' perceptions of having a voice and choice in those academic activities in which they are engaged. (p. 139)

Unfortunately, there is growing evidence that teachers who do not feel they have autonomy in their role are less likely to teach in an 'autonomy supportive manner' (Niemiec and Ryan, 2009). For example, Pelletier, Séguin-Lévesque and Legault (2002) found, in their study of Canadian teachers' motivation and behaviour, that where teachers felt less autonomous due to perceived pressure from school management, they were more controlling with their students regarding factors such as the curriculum and performance standards.

Student perception of control can also be related to the use of rewards in the classroom as students may perceive being rewarded to be controlling of their behaviour and lead them to feel that they are not engaging with the activity of their own free will (Deci, Koestner and Ryan, 1999). As a result, it has been suggested that the offering of tangible rewards, as opposed to praise, reduces interest in a task, although there is some debate in the field of behavioural psychology as to whether or not this effect is genuine (Carton, 1996; Dickinson, 1995).

The role of group work in developing interest

Blatchford *et al.* (2003) argue that the various 'groupings' students are engaged in within a classroom form an important aspect of their school experience:

> If the relationships between grouping size, interaction type and learning tasks are planned strategically then learning experiences will be more effective. However, research … suggests that the relationships between these elements are often unplanned and the 'social pedagogic' potential of classroom learning is therefore unrealised. (p. 2)

Hidi and Renninger (2006) highlight the role that others can play in supporting each stage of the development of interest, referring to 'group work' when discussing Situational Interest and stating that 'peer support' can play a role in developing Individual Interest. There are a number of theories as to why certain social contexts and peer interactions trigger an emotional response or shape an individual's disposition towards wanting to engage with a particular activity. One explanation is the facility of group work to allow students more autonomy in their learning, the importance of which is discussed above. When used effectively, group work shifts the balance of control away from the teacher, although they have a supportive role to play, and moves it increasingly towards the students (Blatchford *et al.*, 2003).

Alternatively, group work and peer support may provide a setting which can help build an individual's competence or perception of their competence. Researchers have explored this idea further and found that environments supporting the building of competence also increase an individual's interest level; similarly, interest is reduced when the setting diminishes competence (for example, see Harackiewicz, Abrahams and Wageman, 1987). Vallerand and Reid (1988) also found a clear link between the effects of feedback on students' interest, with positive feedback increasing interest and negative feedback significantly reducing it. Although these studies were, in the main, focused on the feedback and learning environment constructed by the teacher, the role of peers in building individuals' feelings of competence cannot be ignored. The effect of increased competence on interest will not be maintained if the individual does not have a sense that they have personally contributed to this competence (Ryan and Deci, 2000b) and therefore the perception of choice and control in learning, discussed above, is a crucial factor in supporting the development of interest.

The role of practical work in increasing student interest

Despite the importance which is placed on practical work in science lessons there has been little research specifically into the role that practical work may play in influencing student interest in learning science. One such study found that practical tasks which formed 'memorable episodes' were considered to be rare or vivid (White, 1990). These are similar characteristics to those which Wade, Buxton and Kerry (1999) and Hidi and Anderson (2015) found to be held by texts which increase students' Situational Interest. Other research has found that practical work has a role to play in stimulating Situational Interest, but is less likely to support the development of Individual Interest (Abrahams, 2009). Toplis (2012) interviewed students and found that they valued practical work as it was seen as providing a "sense of fun, personal relevance, personal involvement, motivation and the opportunity of working together that raised interest" (Toplis, 2012, p. 538). In line with other research, for example, Osborne and Collins (2001), student responses indicated that practical work could increase interest due to offering a sense of autonomy, supporting learning or being preferable to alternative learning activities.

Abrahams (2009) also found that absolute liking of practical work in science, rather than liking relative to other activities, was highest for students in the first year of secondary school and concluded that this may be because "many of these practical tasks provide the first opportunity to use scientific equipment and/or materials" (Abrahams, 2009, p. 2343). Liking practical work, however, does not necessarily develop into interest in the task. Interest is characterised by students, in addition to feeling positive, increasing their knowledge of the task and seeking to re-engage with the activity, thus, having the potential to develop their interest further. Moreover, it is possible for students to manifest Situational Interest in a specific practical activity but to not have any specific cognitive engagement in the theoretical basis for it. Therefore, students may not increase their understanding of the abstract scientific concept or theory which the teacher may be attempting to illustrate through the use of practical work (Bergin, 1999; Blumenfeld and Meece, 1988). One possible explanation for a lack of both interest and cognitive engagement is that students may view practical work as somehow separate or a departure from learning science (Abrahams, 2009). Another key finding from Abrahams (2009) was that, in the school studied, the absolute liking of practical work decreased over time to become a preference for practical work over other types of activity such as writing. This, therefore, suggests that practical work is a useful tool for triggering Situational Interest in particular lessons but has less of a role in supporting learning or the development of Individual Interest.

2.7 Student views and student voice

The term 'student voice' refers to the views of young people and the act of engaging them in discussions about teaching, learning and wider issues in schools. 'Student voice' has the potential to be a powerful and influential tool in shaping a school, both in terms of classroom practice and wider school initiatives and developments (Rudduck and Fielding, 2006) and as such has, in recent years, been the focus of much educational research.

Much of the research discussed above has directly asked students their views regarding interest in, and the purpose of, science education. For example, the ROSE project used a survey to ask 15 year-old students, in almost 40 countries, about their attitudes towards school science. Although the students were asked, among other things, about their interest level in learning different science contents in differing contexts there were no questions relating to how this information was taught, and how that may affect student interest (Sjøberg and Schreiner, 2010). Similarly, the studies included in Jenkins' review of student voice in science education (Jenkins, 2006) regarding student interest focus around the different science topics covered in school curricula. When discussing whether or not students have an interest in science, Häussler and Hoffmann (2000) argue that a further distinction must be made when discussing students' interest in science content. They suggest the need to distinguish between *domain interest* (i.e. interest in biology, chemistry, earth sciences or physics) and *subject interest* (i.e. the particular subject (topic) within a domain, e.g. health, biodiversity, genetics and mammoths within biology). There have been a substantial number of studies (for review, see Jenkins, 2006) which examine students' interest and enjoyment of science domains and subjects within those domains. Many of these have reported similar findings such as students, particularly girls, feeling more positive towards the biological than the physical sciences. These studies are valuable when trying to understand and inform science education, although there are numerous studies which highlight a mismatch between topics students report being interested in and the topics included in school science curricula (e.g. Häussler and Hoffmann, 2000; Trumper, 2006).

It can be argued that it is important for teachers to have an understanding of which topics students generally find interesting. However, for a science teacher standing in front of a class, knowledge and understanding of the findings discussed above could, at worst, be detrimental to their teaching. If a teacher enters a classroom believing that the students will not be interested in what he/she has to teach, this belief, and the associated apprehension, is likely to be reflected in many facets of the teacher's behaviour. This may then create a self-fulfilling prophecy as students will pick up on this unease and may interpret it as the teacher having no interest in, or lacking confidence about, the content.

Given the current situation where the content to be covered is prescribed by the examination specifications my study is concerned with finding out about factors which may be used to support the development of student interest. However, there is little research that has examined students' views regarding which activities could increase their interest in learning science in a school classroom and as such there has been little impact on pedagogy (Jenkins, 2006). Furthermore, at the time of writing his seminal review, Jenkins (2006) found that there were no studies which asked students their views on how they would like to be taught science in school classrooms.

2.8 Overview of the study and research questions

As outlined above, there have been a number of attempts to model the development of interest over time and investigate the factors which can support the development of interest through triggering Situational Interest and helping this to become internalised into

Individual Interest. However, none of the current models has focused specifically on interest in learning science. There have been some studies into what aspects of science interest students but often these have focused on their topics and domains to be learnt, rather than pedagogy. Furthermore, there has been limited research into how students view the purpose of science education, a concept which is closely linked with interest in learning science. Therefore, this thesis was designed to add to the current body of knowledge surrounding interest and science education. Since the vast majority of science learning for students aged 14-16 years-old takes place in their science lessons it was decided that the context for this research should be GCSE science classes with an emphasis on the comparison between the views of different groups (male and female students, students from four different schools and students from different ability groups within those schools) of students. Measures of student interest, along with Interest Factors and Purpose Factors, were generated using a questionnaire at the start of the study and a case study was carried out in one school, over two academic years, to investigate these factors in a real-life setting. The study was conducted from June 2012 to June 2014 to address the following research questions:

- What factors do students believe influence their interest in learning science between 14 and 16 years of age and does a student's school, gender or ability grouping relate to these beliefs?
- What do students believe is the purpose of studying science between 14 and 16 years of age and does a student's school, gender or ability grouping relate to these beliefs?
- To what extent are teachers aware of 14 to 16 year-old students' beliefs regarding factors which influence interest in, and the purpose of, studying science?

- Is it possible to increase students' interest, specifically their Situational Interest, in learning science through adjustments to existing approaches to teaching?
- How can teachers be supported in developing their classroom practice with a view to increasing students' interest levels?

Chapter 3: Methodology and methods

The aim of this study is to investigate factors that influence the development of interest in science education, including the expression and communication of students' and teachers' perspectives.

3.1 Epistemological and theoretical standing

Research investigating teaching and learning tends to focus on teaching activities such as practical work or group work. Studies that examine the effects of interest and expectations of pupils and the purpose of lessons in particular subjects are very much in the minority. This study, as outlined in the previous chapters, adopts this latter approach and in doing so seeks to add to the existing body of knowledge.

This research has been conducted from a constructionist viewpoint where "meanings are constructed by human beings as they engage with the world they are interpreting" (Crotty, 1998, p. 43), taking into account the social, historical and cultural context in which we base this interpretation. This can be contrasted with a constructivist perspective that can be understood as focusing solely on the individual's role in constructing knowledge. Although interest, the subject of this thesis, is generated by an individual's interaction with artefacts (see Section 2.2 for discussion), the interpretation and labelling of the feelings and knowledge generated by this collective understanding of what it means to be 'interested', formed through interactions with others. Our understandings of what it means be to a teacher or a student, to be in a science lesson or engaged in learning, are shaped by the culture in which these things occur and individuals grow up in communities where the collective understanding of these concepts is typically relatively stable. For example, individuals who live in England have a collective, if somewhat broad and generalised, understanding of what it means to be a teacher or a student. This perception of these roles will differ between different countries to a greater or lesser extent based on cultural norms, for example, whether or not girls are expected to attend school or the behaviour management strategies that it is acceptable for teachers to employ. Furthermore, the understanding of these roles may vary between smaller communities, such as schools within England, which could lead to variation in how these roles are enacted by individuals.

The overall approach of this research has been holistic to enable investigation of how the various important factors are interconnected and related. To allow in depth study this work is highly contextualised to the schools, students and teachers who provided the relevant data. Each participant in this investigation is embedded within its own specific community, defined by geographical area, social groupings and professional interactions. These interactions develop and exist in many guises, from one-to-one situations up to large groups. As a result of these interactions the 'social world', which is the subject of this thesis, is already constructed with its own meaning (Blaikie, 2007), crucially, in the case of this study, I am already integrated into this social world. However, the in-depth nature of the study and my personal involvement as participant-researcher risks bias in interpreting data and evidence and/or misrepresentation of colleagues' and pupils' views. Therefore, in developing the questions and methods, set out below, possible alternative perspectives have been considered including different epistemological or pedagogical stances, which may be held by participants. Similarly, these alternative perspectives have been considered when contemplating the conclusions to be drawn from the data.

The data have been considered from an interpretative position (Crotty, 1998) in order to better understand, rather than explain, the influences on student interest with regards to learning science within the context of science lessons for students between 14 and 16 years-old in schools in North-West England. The branch of interpretivism known as symbolic interactionism was considered to be the most appropriate theoretical perspective to be adopted for this thesis, as Blumer (1986, p. 2) states:

> The first premise [of symbolic interactionism] is that human beings act towards things on the basis of the meanings that things have for them. The second premise is that the meanings of such things is derived from, or arises out of, the interaction that one has with one's fellows. The third premise is that these meanings are handled in, and modified through, an interpretive process used by the person in dealing with the things he encounters.

With regards to these premises: first, it is proposed that both teachers and students act towards school and lessons based on their beliefs about them and the meanings that they have for them; second, these beliefs and meanings are, for the most part, a result of engaging within the culture of a specific school and local community; third, individuals will seek to understand these beliefs and meanings through their on-going experiences. This thesis is strongly grounded in human behaviour and the interactions individuals have with people, events and knowledge within a specific social setting – teachers and students in science lessons within secondary level (11-16 / 11-18) comprehensive schools in England. Furthermore it has increased knowledge of what students and teachers understand about, and believe to be important in, increasing student interest in learning science.

Symbolic interactionism is most frequently associated with qualitative research methods, however, the underlying assumptions of this perspective can also be applied to quantitative research (Benzies and Allen, 2001). In this thesis the quantitative analysis serves to provide information regarding what students and teachers believe. It has then been possible to further scrutinise these beliefs, and how interactions may have shaped them, through the collection of the qualitative data.

3.2 Overall structure of the study

This research had been planned, from the outset, to be completed part-time alongside my teaching and departmental responsibilities; as a result of this I was able to plan to collect data over a period of time to investigate students' interest levels in the context of normal science lessons. Survey and case study methodologies, using questionnaires and ethnographic data collection methods, were considered to be the most appropriate as they follow naturally on from the constructionist traditions and allowed collection of both qualitative and quantitative data. Furthermore, these methodologies reflected my dual role of researcher and participant within the community of School A. The different data collection methods and overall structure of the study are summarised in Figure 3.1.

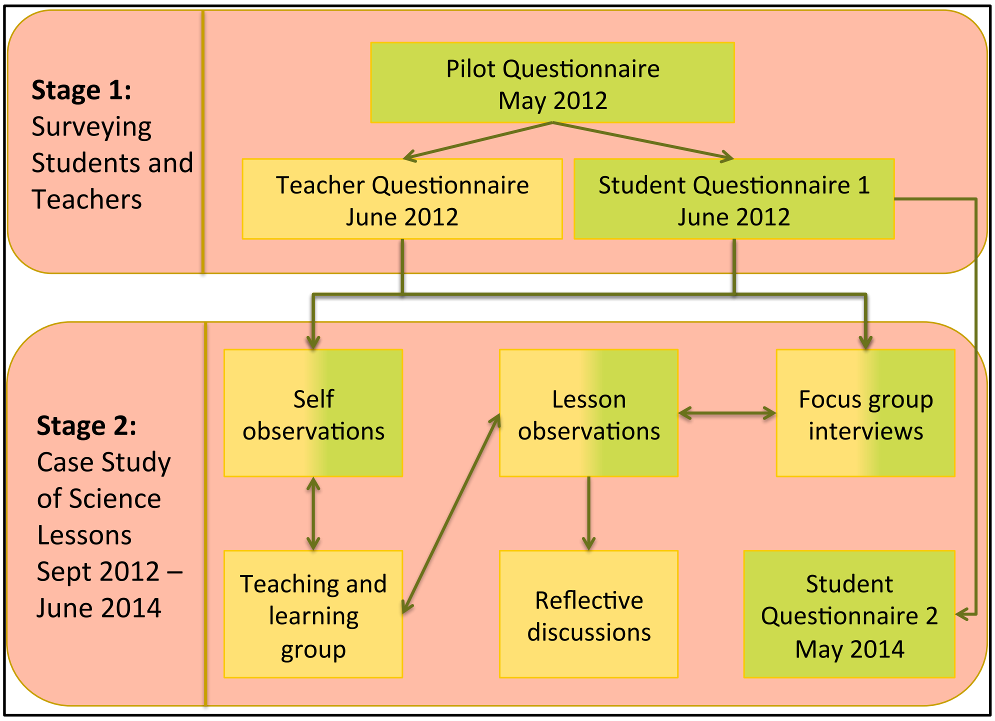


Figure 3.1 The overall structure of the study with regards to data collection activities during each of the two stages. Yellow indicates activities which involved teachers and green indicates activities which involved students.

Stage 1 of the research was to construct and administer two questionnaires: (a) Student Questionnaire 1 to measure students' levels of interest in and their views on factors which increase their interest in studying science as well as the purpose of studying science between 14 and 16 years of age; (b) Teacher Questionnaire to assess teachers' beliefs about what they think the students consider to be the factors that influence student interest in studying science and students' views of the purpose of studying science.

The Pilot Questionnaire was developed and tested as outlined below (pp. 85-106) and used to generate Student Questionnaire 1 and the Teacher Questionnaire. Student Questionnaire 1 was completed by 475 student participants from four different schools (see Box A in Section 3.3) and the Teacher questionnaire was completed by 11 teachers, all of which worked at one of the schools attended by the student participants. The data collected from these questionnaires was processed and then used to inform Stage 2. This took the form of a case study of science lessons within School A. Qualitative data was collected over two academic years from self-observations, lesson observations, reflective discussions following lesson observations and focus group interviews with both groups of students and groups of teachers. The initial conclusions from Stage 1 were used to inform planning for the self-observed lessons and structure the focus group interviews, which in turn, influenced the teacher participants when planning lessons for GCSE Science classes. The final data collection episode was Student Questionnaire 2 which measured the students' level of interest in studying science at the end of the two years of studying GCSE Science. This questionnaire was completed by students (n = 42) from two of the classes observed as part of Stage 2.

Figure 3.2, adapted from Cohen, Manion and Morrison (2011), summarises the nature of the different data collection methods. Cohen, Manion and Morrison's (2011) original diagram describes the nature of observations, however, the continua, apart from participant observation/non-participant observation, can also be applied to other data collection methods. As detailed in Figure 3.2 the stages of data collection (see Figure 3.1) allowed for a broad spectrum of methods to be used. The questionnaires, Student 1 and Teacher in Stage 1 and Student 2 in Stage 2, were overt, pre-specified and highly structured to collect quantitative data which provided a descriptive snap-shot of students' and teachers' views at the time of data collection. The methods employed in Stage 2, however, allowed collection of qualitative data in an unstructured and responsive manner with the aim of providing explanations of behaviours, and how interactions shape students' and teacher beliefs, when they occur in a more naturalistic setting.

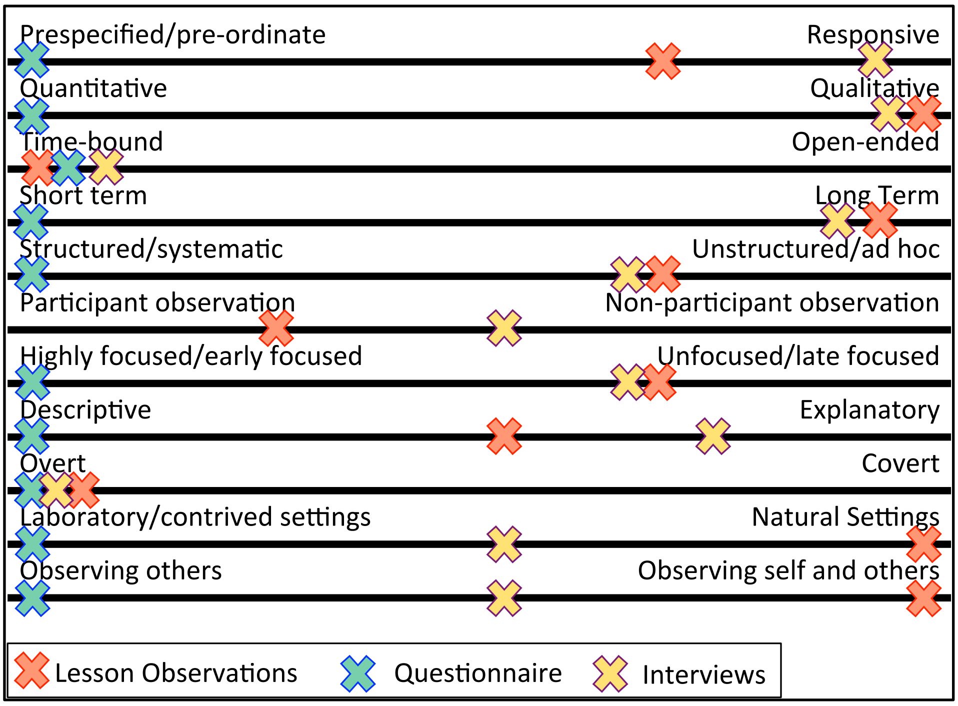


Figure 3.2 The nature of each of the data collection methods utilised in this thesis. Adapted, and extended, from Cohen, Manion and Morrison (2011).

The longitudinal nature of the study provided an opportunity to collect rich and varied data using three main methods; observations, questionnaires and interviews, which complemented each other and allowed for triangulation of evidence to provide secure conclusions. The questionnaires and interviews asked all participants about their beliefs and attitudes towards learning science, within the contexts of this study, whereas the lesson observations provided an opportunity to see how, and if, both teachers and students enact these beliefs through their behaviours in science lessons. Finally, although this study could not be defined as 'action research' the activities undertaken provided an opportunity to investigate the potential for increasing student interest in learning science through teachers placing greater emphasis on the Interest Factors and Purpose Factors generated from the questionnaire data collected in Stage 1.

3.3 Methods

The starting point of the research was to investigate the views of 14 to 16 year-old students and their Science teachers with regards what factors they believed make students more interested during Science lessons and what they believe to be the purpose of learning Science at GCSE level (14–16 years of age). A survey methodology was chosen to allow a quantitative comparison of the expectations and understandings of the participants. Once these data were collected and analysed the second stage of the research focused on collecting qualitative data from a smaller number of participants, both students and teachers via interviews, focus groups and lesson observations, thus following a case study methodology. This stage of data collection allowed particular factors to be explored in more depth as well as the investigation on how certain factors were interconnected and the impact they had in the classroom

Stage 1: Surveying teachers and students

A questionnaire (see Appendix 1 for Student Questionnaire 1 and Appendix 2 for Teacher Questionnaire) was used to establish baseline data for the expectations and views of the participants. Specific sections of both the student and the teacher questionnaires were the same to allow direct comparison of the responses given by the students to those of the teachers. The questions enquired about the participants' beliefs; what they think is true, and attitudes; what they think is desirable (de Vaus, 2002). No questions were included which focused solely on student or teacher behaviours as data regarding these were collected through the lesson observations and interviews. The lesson observations allowed a comparison of participants' beliefs, expressed through the questionnaire and interviews, with their behaviours when teaching. The questionnaire allowed the collection of a substantial amount of data which provided a breadth of information and allowed comparison of the expectations of teachers and their students.

An advantage of using anonymous questionnaires is that they are less likely than face-to-face interviews to lead to social desirability bias in participant responses. Some previous studies (for example, Osborne and Collins, 2001) have collected the views of teachers and students through focus group discussions and interviews. These methods have the obvious disadvantage that participants may feel exposed and threatened when answering and discussing these issues in front of others. The use of questionnaires has the added advantage of allowing the collection of a relatively large sample of data in a shorter time scale than would be needed if using interviews.

A common disadvantage of using a questionnaire is that it is difficult to follow up participants' responses (de Vaus, 2002); however, the questionnaire used for this research requested some personal information, including initials and date of birth. This allowed individual student responses to be categorised in terms of ability grouping within schools and also allowed comparison to the responses to a second questionnaire which was completed by two classes of students in School A.

<u>Sample</u>

The schools involved in this study were selected for a practical reason of access; I work in one of the schools and had access to the other schools via colleagues. In addition, they represent differing types of school (see Box A) and thus teachers and students from different contexts. Participants were selected from two main populations from four schools: secondary science teachers and 14-16 year-old students. Different sampling methods were employed for the students and the teachers due to the nature of these populations. Teachers from four schools in the North West of England were invited to complete a questionnaire and ask the students in their classes to complete Student Questionnaire.

Teachers: All of the teacher participants work within one of the schools attended by student participants and all teach an element of the science course to the 14-16 year-old students in their schools. The final volunteer sample, which completed the Teacher Questionnaire, consisted of 11 teachers: 3 female and 5 male teachers from School A, and 1 male teacher and 2 of undeclared gender from School D.

Students: The student data were collected via opportunity sampling of the cohort of students who entered 'Year 10' in September 2012, which meant that they were 14 years old on the 1st September 2012. A total of 475 student questionnaires were completed. Details of the student demographics can be seen in Table 3.1. As is common practice in schools in England all of the schools in this study place their students in particular classes, 'sets', for the start of the Key Stage 4 courses, if not before. Which set a student is placed in is based upon their prior attainment in either internal or external examinations as well as teacher assessment of a students ability / suitability for a particular qualification. The students who achieve the highest levels are placed in ability set 1, with students with lower scores being placed in to set 2 and so forth and with set 4 comprising of students with the lowest levels of prior attainment. The differing number of students in each ability set (see Table 3.1) is a result of the number of students placed in each set reflecting student ability, as is the case in the majority of schools. Therefore as set number increases, the number of students within that set decreases to provide a higher teacher: student ratio in lower ability sets.

Table 3.1 The number of students in each group of student participants. In each of the schools there were two classes for each of the ability sets with relatively similar proportions of female and male students. '?' indicates the number of students who did not provide information regarding their gender or ability set.

Ability Set	School										Total
	A			B			C		D		
	M	F	?	M	F	?	M	F	M	F	
1	32	29		26	26		7	22	22	31	196
2	25	31	2	18	9	1	12	15	17	10	139
3	32	21		18	17	1	0	0	0	0	89
4	16	12		15	6		0	0	0	0	49
?	1	1									2
Total	202			137			56		80		475

Box A: Pen portraits of the schools involved in this study

School A, located in Cheshire, is a mixed comprehensive school, although it was previously a grammar school. It has a roll of around 1350 students been the ages of 11 and 18 years. Within the science department each cohort is divided into two bands and within the bands the students are placed in one of four ability sets, based on prior test scores, for each of the first three years (Years 7 to 9, ages 11 to 14). At the end of Year 9, students select the subjects they would like to study at GCSE level. As part of this process they are allowed to select to study Separate Science GCSEs (one in each of Biology, Chemistry and Physics) to fill one of the option spaces. Those students who do not choose the Separate Science route study the equivalent of two Science GCSEs. At the time of the data collection for this research, these two GCSEs were Science GCSE, the content of which was covered in Year 10, and Additional Science GCSE, delivered in Year 11.

School B is a mixed comprehensive school in Lancashire. It has a roll of around 720 students between 11 and 16 years of age. In contrast to School A, students at School B embark on their GCSE studies in Year 9, aged 13 years, although they are still given the option to study the Separate Science GCSEs in place of another subject or to work towards two Science GCSEs, each of which contain elements of Biology, Chemistry and Physics. The students who complete the two Science GCSEs are set by ability and remain in these sets, unless there is a specific reason for them to move, until the end of the course at 16 years of age.

Box A continued . . .

School C, in Lancashire, has around 760 students between 11 to 16 years of age and is a mixed comprehensive school. Students start their GCSE courses in Year 9 and are placed into tiered sets, based on their performance on internal examinations at the end of Year 8 (age 13) and half way through Year 9 (age 13-14). The cohort is divided into two bands and the students in the top ability set in each band study towards the Separate Science GCSEs whereas the students in the other sets undertake the Combined Science GCSEs, working towards two GCSEs.

School D has around 2010 students between 11 to 18 years of age and is located in Cheshire. This is a mixed comprehensive school located near a selective grammar school. Within the science department each cohort is divided into two bands and within the bands the students are placed in one of six ability sets, based on prior test scores, for each of the first three years (Years 7 to 9, ages 11 to 14). During the summer term of Year 9 all classes complete one unit of Core Science GCSE and at the end of Year 9, students select subjects to study for GCSE level. As part of this process those students who achieve the standard set by the school were allowed to select to study Separate Science GCSEs, one in each of Biology, Chemistry and Physics, to fill one of the option spaces. Those students who do not choose the Separate Science route followed one of three routes, depending on the ability set they are placed in. The majority of the students take Core Science and Additional Science GCSEs, a small number of students take Core Science and Additional Applied Science GCSEs and the students in the lowest ability set of each band study Core Science GCSE over two years.

Pilot research: development of student and teacher questionnaires

The pilot questionnaire comprised four sections:

1) Factors which affect the development of interest
2) Perceptions of the purpose of science
3) Measuring an individual's level of interest
4) Additional areas of interest.

There is a reasonable amount of previous research into factors that help to foster Situational Interest; however, there is comparatively little published research into external factors which support the development of Individual Interest. This is unsurprising as Individual Interest is internal to the individual and their relationship with the content and is therefore more difficult to support.

The majority of the questions in sections 1, 2 and 3 are stand-alone statements that require responses on Likert scales. Sections 1, 2 and 4 also include open-ended questions that required students to write longer answers. All questions were kept simple and there were only a small number of question styles to avoid over complicating the process for the participants. The majority of questionnaire items were closed, as opposed to open, questions. Within the context of this research closed questions, which require a scaled response, have a number of advantages, one of which being that they are more reliable to code; the participants are classifying their views rather than me having to infer these views from prose (Tuckman, 1999). The participants also find these questions quicker to answer; an advantage if they are less motivated. In addition, closed questions have been found to be less intimidating for participants who are less able to articulate their views through free-writing (de Vaus, 2002). This is an important consideration as the questionnaire was designed to be administered to students of all abilities, including those who may have poor literacy skills. Likert scale questions have been used to assess the direction and strength (de Vaus, 2002) of participants' beliefs and attitudes; the intensity of these were investigated further during Stage 2 of the research. Where Likert scale questions are used both positive and negative statements have been incorporated to check the reliability of responses and also neutralise the effect of participants who just tick 'agree'; further discussion of this can be found with the discussion of the pilot study. Although there is on-going debate (for discussion, see Oppenheim, 2000) as to the inclusion of a ‘no opinion’ or ‘don’t know’ response option in attitude questions, I included this alternative as a ‘neutral’ option to provide for those who have no overall opinion. Since the majority of the questionnaires have been self-administered, as a result of them being sent to the schools for completion, I strived to ensure the instructions and questions were clear and simple, but also included five alternative responses for each item and few extreme statements to ensure the questions are sensitive enough to show real differences in the responses (de Vaus, 2002).

Pilot Questionnaire Section 1: Factors which affect the development of interest

The statements included in Section 1 came from three main sources: the Student Interest in Mathematics questionnaire (Mitchell, 1993); Tamir and Gardner (1989); and my own understanding of Interest.

Mitchell’s (1993) questionnaire contains a good mix of positve and negative statements which allow internal reliability and validity to be checked. Mitchell (1993) developed his model of interest and then used these statements to test relationships between each of the aspects of his model; therefore, many of the items relate to activities which students believe may increase their interest in learning mathematics. As such, these items have been modified by me to reflect learning in science, rather than in mathematics. However, some of the categories may not be relevant to Key Stage 4 science teaching; for example, ‘puzzles’ may actually represent challenge, as discussed in Hidi and Renninger’s (2006) model (see Section 2.2, p. 36), but are not a common method of introducing challenge into science lessons so this is not a reliable way of assessing interest in science lessons. Similarly, the inclusion of ‘computers’ may lack temporal validity as technology is much more commonplace in students’ lives, therefore does not now have the novelty value it may have had in 1992. At the time of this research ‘computers’ was taken to encompass other devices (e.g. iPads) which were beginning to be introduced into the classroom to support teaching and learning. However, there was no overall reason to omit computer use from the questionnaire and therefore, an item relating to the use of computers in the lesson was included. Furthermore, there are issues with a number of statements as they cover more than one point and the participants could interpret them in different ways, e.g. ‘I like the groups in our class because learning is more fun when things can be discussed’ could be answered with a focus on ‘the people in the groups’, ‘groups being fun’ or ‘discussions’, all of which can be linked to, or independent of, learning. These concerns were addressed by breaking down complex statements into a number of items, each of which focused on one specific activity. For example, the above statement was used to generate the following three statements:

- Being able to discuss the topic with my teacher
- Being able to discuss the topic with the rest of the class
- Working in small groups.

Tamir and Gardner (1989) categorised aspects of lessons that may increase student interest as ‘Activity Motives’ and developed five subsets: utilitarian, instrumental; independent experiences; active teacher; exploring/problem-solving; and logical thinking. Another aspect they investigated was ‘Preference of Learning Modes’. Four factors emerged, each constituting a separate subset, which were: experiential learning; reception learning; studying summaries; and social interaction. A number of the original statements which made up these nine subsets were generalised from biology specific items to encompass all aspects of science.

Tamir and Gardner (1989) investigated learning mode preference to assess how students preferred to learn and compared the relationship between interest and this preference. They only found one significant correlation, which was a negative relationship between level of interest and a preference for studying summaries.

Other research (for example, Planet Science, 2003) has investigated which types of activities students prefer, and which aspects they feel help them learn most effectively, and found that students are aware of differences between what they enjoy and what helps them to learn. This dichotomy was not explored here since one of the premises of this project was the belief that increasing interest increases attainment, and therefore effectively structuring learning to support the development of interest should have a positive impact on student attainment. Furthermore, statements which try to ascertain why each factor increases interest were not included as there are too many possible reasons all of which could not possibly be covered, without the questionnaire becoming unwieldy. The explanations for why certain factors increase interest were investigated through Stage 2 of the project using observations and interviews as these methods were expected to yield responses that are more valid.

The importance of prior knowledge has been highlighted in a number of pieces of research into factors which increase interest (Alexander, Kulikowich and Schulze, 1994; Schraw, Flowerday and Lehman, 2001). However, this factor does not appear to be assessed by any existing surveys. There is research to suggest that topic knowledge and domain knowledge influence interest to different extents (Alexander, Kulikowich and Schulze, 1994). However, it is difficult to measure the extent to which an individual believes that domain knowledge will impact their interest as it would require them to imagine that they know either more or less about science and then judge what effect that would have on their level of interest. Therefore, the following statements were included in an attempt to assess the relative importance students place on prior knowledge in relation to supporting the development of interest:

- If I already know something about the lesson topic

- If I can see the links between new information and something I have previously learnt
- If I know something about the area of science we are studying.

A complete list of statements included in Section 1 of the pilot questionnaire, where they were adapted from and how they relate to 'interest' can be found in Table 3.2.

Table 3.2 Statements included in Section 1 of the pilot questionnaire.

Activity / Opportunity Statement	**Theoretical interest factor**	**Adapted from (if applicable)**
Being able to discuss the topic with my teacher	Personal involvement (Mitchell, 1993)	Mitchell (1993)
Being able to discuss the topic with the rest of the class		Mitchell (1993)
Doing something instead of the teacher just talking		Mitchell (1993)
Carrying out practical work		
Working in small groups		Mitchell (1993)
If I feel I have control over my work		
Feeling I know what I should be doing		
Being given responsibility for my work and learning		
If I am given challenge	Challenge and puzzles (Mitchell, 1993) Challenge through models	
If I have to think about the ideas		
Using models to explain difficult theories		
Doing drama to model scientific ideas		
Doing logic puzzles		Mitchell (1993)
Doing mind teasers		Mitchell (1993)
Having the opportunity to solve problems		Mitchell (1993)
Doing tasks which will help me prepare for examinations	Value (Wade, Buxton and Kerry, 1999) and Meaningful activities (Mitchell, 1993)	Tamir and Gardner (1989)
Doing things which are related to my future career		Tamir and Gardner (1989)
If I can see the science we're learning is important in life		Tamir and Gardner (1989) & Mitchell

		(1993)
Learning information which is relevant to me		Tamir and Gardner (1989) & Mitchell (1993)
If it helps me understand how the world works		Tamir and Gardner (1989) & Mitchell (1993)
Having the opportunity to carry out independent studies	Meaningful choices (Schraw, Flowerday and Lehman, 2001)	Tamir and Gardner (1989)
If I am supported in making good choices		
If there is feedback on the choices I have made		
Having the opportunity to explore the unknown	Novel information (Wade, Buxton and Kerry, 1999)	Tamir and Gardner (1989)
If I learn strange facts		Tamir and Gardner (1989)
If I already know something about the lesson topic	Background knowledge (Schraw, Flowerday and Lehman, 2001)	
If I can see the links between new information and something I have previously learnt		
If I know something about the area of science we are studying		
Using computers in our class	Computers (Mitchell, 1993)	Tamir and Gardner (1989) & Mitchell (1993)
Being able to pick the topic I will study	Choice	
Being able to present the information in a way I choose		
If I have a sense of achievement	Increasing Knowledge	
If the teacher is interested in the lesson		
Learning the information in different ways		
Watching the teacher demonstrate an experiment		
Developing a better understanding of scientific concepts		
Developing an understanding of the links between topics		
Doing well in tests or assignments		

Pilot Questionnaire Section 2: The purpose of studying science

Unlike the other two sections there is little empirical research as to what students, teachers and parents consider to be the purpose of learning science and as such no pre-existing questionnaires were identified that investigate this topic. Therefore, the statements for this section were developed using conclusions, both research and theoretical, from a number of different sources (see Table 3.3). The challenge in developing this section of the questionnaire was bringing together the numerous perspectives on the purpose of science education presented in the literature from a broad spectrum of stakeholders including education researchers, teachers, curricula designers and examination boards (see Section 2.6). In addition, the individual statements included in the final questionnaire needed to resonate with both the student and teacher participants.

Table 3.3 Statements included in Section 2 of the pilot questionnaire.

Statement	**Type of Purpose**	**Links to research**
To learn scientific facts	Academic	
To learn some scientific theories	Academic	
To prepare me to get a GCSE in science	Academic assessment / Reliable and useful knowledge	Jenkins and Pell (2006); Millar and Osborne (2006)
To interest me and make school enjoyable	Interest	Millar and Osborne (2006)
To make me more interested in science	Interest	For example, Hidi and Renninger (2006)
To teach me about how to be healthy	Personal	Van Aalsvoort (2004b)
To give me confidence when making decisions	Personal-social / Reliable and Useful knowledge	Jenkins and Pell (2006); Millar and Osborne (2006); Van Aalsvoort (2004b)
To help me make decisions about scientific issues	Personal-social / Democratic	Millar and Osborne (2006); Van Aalsvoort (2004b)
To teach me things which will be useful for a job	Professional /Reliable and useful knowledge	Jenkins and Pell (2006); Van Aalsvoort (2004b)
To teach me how to use different types of scientific equipment	Professional	Van Aalsvoort (2004b)

To learn how scientists investigate the world	Professional	Van Aalsvoort (2004b)
To explain how scientific investigations are done	Professional	Van Aalsvoort (2004b)
To prepare me for my future career	Professional	Van Aalsvoort (2004b)
To teach me how to interpret scientific data	Professional / Democratic	Millar and Osborne (2006); Van Aalsvoort (2004b)
To train people to be scientists	Professional / Economic	Millar and Osborne (2006); Van Aalsvoort (2004b)
To learn about different scientists	Social	Van Aalsvoort (2004b)
To help me understand current environmental issues	Social / Reliable and useful knowledge	Jenkins and Pell (2006); Van Aalsvoort (2004b)
To understand what science has achieved	Social / Cultural	Millar and Osborne (2006); Van Aalsvoort (2004b)
We all learn science because the country needs scientists	Social	Van Aalsvoort (2004b)

Pilot Questionnaire Section 3: Measuring an individual's level of interest

Section 3 of the pilot questionnaire contained statements which aimed to measure both Situational and Individual Interest (Hidi and Renninger, 2006). Again, the items for this section of the questionnaire were adopted from existing measurement tools. In total five sources of statements were used:

- the Science Opinions Survey (Gibson and Chase, 2002)
- the Attitude Towards Science in School Assessment (Germann, 1988)
- Hulleman and Harackiewicz (2009)
- Tamir and Gardner (1989)
- the Student Interest in Mathematics questionnaire (Mitchell, 1993).

Items from The Science Opinions Survey (Gibson and Chase, 2002) and the Attitude Towards Science in School Assessment (Germann,

1988) were considered as these are some of the only surveys that cover affective components of interest. Hulleman and Harackiewicz (2009) and Tamir and Gardner (1989) both created surveys that have been demonstrated to have high levels of reliability and have clearly written statements. However, neither of these tools distinguish between Situational Interest and Individual Interest and therefore the statements needed categorising against the Four-Phase model of interest described by Hidi and Renniger (2006) and discussed in Section 2.2, p. 36. In addition, the items taken from Tamir and Gardner (1989) were edited by me to make them relevant across all science disciplines rather than being specific to biology. Similarly, the statements used from Mitchell's (1993) Student Interest in Mathematics questionnaire, have been re-written to reflect science rather than mathematics. One limitation, in the context of this study, of the Student Interest in Mathematics questionnaire (Mitchell, 1993) is that the statements were used to generate a model of interest, rather than specifically measure interest levels. Although there is evidence that engaging in certain activities can increase interest it cannot necessarily be inferred that the students are interested just because they do some of these things, e.g. exchange ideas in groups. Therefore, care was taken to ensure that questions relating to aspects which might interest students were included in Section 1 and that Section 2 assessed the level of interest students had at the time of completing the survey. A strength of the Mitchell (1993) survey is the use of both positive and negative statements which allows reliability to be checked.

The main issue encountered with all of the surveys was that they do not explicitly relate the instruments to a theoretical framework or psychological construct. However, I felt that it was important to adopt a framework for the questionnaire and therefore, the pre-existing survey instruments were considered in light of the model of interest adopted here and a new set of items was created to assess students' levels of interest; these are set out in Table 3.4.

Table 3.4 Statements included in Section 3 of the pilot questionnaire.

Statement	Situational or Individual Interest	Adapted from
Compared to other subjects, I feel relaxed studying science	Situational Interest	Mitchell (1993)
Compared to other subjects, science is exciting to me		Mitchell (1993)
I enjoy studying science		Tamir and Gardner (1989)
I have always enjoyed studying science at school		Mitchell (1993)
I look forward to science lessons		Mitchell (1993)
Science lessons are fun		Gibson and Chase (2002)
I can apply what we are learning in our science classes to real life		Hulleman and Harackiewicz (2009)
I can see how what I learn from science applies to life		Hulleman and Harackiewicz (2009)
I think what we are studying in science class is useful to know		Hulleman and Harackiewicz (2009)
I dislike science lessons	Situational Interest (negative)	Gibson and Chase (2002)
I don't find anything interesting about science lessons this year		Mitchell (1993)
My other lessons are more interesting than science		Gibson and Chase (2002)
Science lessons bore me		Gibson and Chase (2002)
Everyone should learn science	Individual Interest	Tamir and Gardner (1989)
I enjoy reading books about science		Tamir and Gardner (1989)
Science is fun		Germann (1988)
I would be glad to work in the school lab during the summer holiday		Tamir and Gardner (1989)
I think the field of science is interesting		Hulleman and Harackiewicz (2009)

Science is enjoyable		Mitchell (1993)
I plan on taking more science courses even when I don't have to		Hulleman and Harackiewicz (2009)
Someday I want to have a job that involves science		Hulleman and Harackiewicz (2009)
Science is boring		Mitchell (1993) Germann (1988)
I cannot see why some people devote their lives to the study of science		Tamir and Gardner (1989)
Investigating scientific ideas which are already understood is a waste of time	Individual Interest (negative)	Tamir and Gardner (1989)
I am not really interested in using science in my future career		Hulleman and Harackiewicz (2009)
To be honest, I just don’t find science interesting		Hulleman and Harackiewicz (2009)
Teachers should make the lessons interesting	n/a	
I am more interested if I put more effort into the lesson	n/a	

<u>The reliability and validity of the survey</u>

The questionnaire elements were drawn from a number of existing sources, e.g. Interest questionnaire (Häussler and Hoffmann, 2000), which have been trialled and verified, in order to improve the validity of the data. A number of the indicators used in existing, published questionnaires are behavioural measures which means that there is a danger when attempting to extrapolate from them to a person’s attitudes (de Vaus, 2002). However, each of these surveys has been assessed for reliability (for example, Mitchell, 1993).

Assessment of the validity of my questionnaire is more difficult as there have been few surveys completed to assess the level of interest, or factors that influence interest as a specific construct, thus making it difficult to ascertain concurrent validity. All items appear to have face validity and, as the items have a strong theoretical basis, should have an acceptable level of construct validity. The validity of the statements was also assessed whilst the questionnaire was piloted as well as during Stage 2 of the research as there was the opportunity to observe and interview students allowing comparison of their behaviours to their survey responses.

A key aspect of the questionnaire which had the potential to reduce validity was the language and scientific terminology used. Therefore, the piloting process allowed the development of succinct and accessible items to be included in the questionnaire. Social desirability bias may have affected the validity of responses to the questionnaire items as there is evidence that people under-report what they perceive to be undesirable behaviours and attitudes and conversely over-report those which they perceive society to view as desirable (for example, Foddy, 2001). In order to address this issue the questions were presented in as neutral a manner as possible and pilot research was used to ensure that they were not offensive in any way. However, due to the nature of the questionnaire items social desirability bias should not have been a significant problem as the research is unlikely to be perceived as socially sensitive as participants were not asked about their opinions relating to topics such as gender and sexuality, race or intelligence.

<u>Pilot study</u>

The participants for the pilot study were a sample of 2011-2012 cohort of Key Stage 4 students (aged 14-16). These students were selected as they did not participate in the main study and therefore avoided corruption of the research sample. They were, however, comparable to the student participants on a number of demographics: age; gender ratio; ability level; reading age. The stages of the pilot research undertaken can be seen in Figure 3.3. The main purpose of the pilot research for Stage 1 was to refine the questionnaire items, through ensuring there were enough alternative responses to each item and checking each question was accessible to all students, both with regards to terminology and to the literacy demand. In addition, the pilot research checked that the questions were not “intrusive, sensitive, irrelevant, repetitive, ‘ ’ poorly worded, difficult to understand, difficult to answer or have insufficient response categories” (de Vaus, 2002, p. 97) which could lead to non-response from the participants. To support the development of the questionnaire, each item was checked against de Vaus’ (2002, p. 97) 17 step checklist.

The pilot study consisted of two separate activities. First, two focus groups of students (n = 8) were asked to verbalise their thoughts on the statements and explain what they thought the statements meant as they completed the questionnaire. This was a declared pilot and the students were aware that it was part of the questionnaire development stage of the research (de Vaus, 2002). All students responded with meanings in line with the intended meaning.

Second, the re-drafted questionnaire, was completed by 103 students, between 14 and 15 years of age, none of whom would be participating in the final research. The results this aspect of the pilot (Figure 3.3, step 8) are outlined, along with the modifications made to the questionnaire, below.

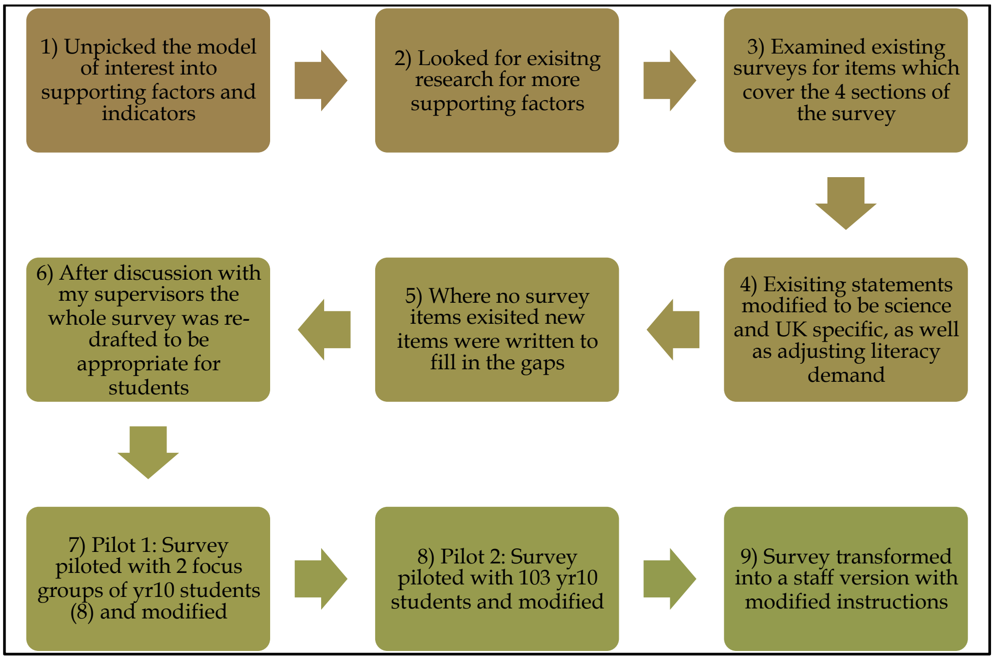


Figure 3.3 Development process for the questionnaires used in the research.

Modifications to the student questionnaire as a result of the pilot study

Section 1: Factors which affect the development of interest

The final question of this section was a free response question: 'Are there any activities, apart from the ones above, which make you more interested in science lessons?' and all of the responses to this can be found in Appendix 3. It is clear from these answers that practical work is important in developing student interest but there is already a statement referring to practical work in the survey. There were a number of activities, opportunities and experiences included in student responses which were not already covered in the draft questionnaire and therefore the following items were inserted into the survey for the main data collection stage:

- When the teacher is knowledgeable
- If I can see the link between the resources and the learning objectives
- If I can see the link between the activities and the learning objectives
- When I can choose who to work with
- Watching videos
- Doing drawings which show scientific ideas
- Making models to help explain scientific ideas.

Section 2: The purpose of studying science

There were a number of suggestions, which can be found in Appendix 4, made in answer to the final question in this section: 'Are there any other reasons for studying science in school?'. Many of these repeated options given in the questionnaire but a number of additional themes emerged:

- To get a GCSE qualification
- As the knowledge and skills are important in life

- To help me to get a job or go on to further education
- So people do not take for granted what has been achieved
- Because it is just so interesting
- To develop ideas about how the world works.

As result of the pilot study these items were be added to Section 2 of the questionnaire (see Appendix 1).

Section 3: Measuring an individual's level of interest

A number of items in this section were presented in the negative and thus required their scores to be reversed when calculating the interest level of each individual. This also allowed a simple assessment of the internal reliability of the items through comparison of the mean for each item across all students. Each item is scored between 0 and 5, therefore since all of the means for the items used to measure Situational Interest (Table 3.5) are within ±0.5 of the overall mean it suggests that the statements have a high level of internal reliability.

Table 3.5 Situational Interest Items; mean score for each statement from pilot study responses.

Item	**1**	**2**	**6**	**7**	**9 neg**	**10 neg**	**12**
Mean	2.76	2.77	3.05	3.29	3.28	3.39	3.14
Item	**13**	**14**	**15**	**19**	**21 neg**	**25 neg**	**Overall**
Mean	3.01	2.82	2.89	3.19	2.49	3.11	3.01

The items designed to measure Individual Interest do not have such similar means (Table 3.6) and therefore have lower internal reliability. As a result of this analysis, item 11 'I enjoy reading books about science' and item 17 'I would be glad to work in the school lab during the summer holiday' were re-written to 'I enjoy finding out about science for myself' and 'I would be glad to do something science-based for my work experience' respectively. The original versions of both of these items came from pre-existing surveys and may therefore not be appropriate for the students in this study.

Table 3.6 Individual Interest Items; mean score for each statement from pilot study responses.

Item	**3**	**5 neg**	**8 neg**	**11**	**16**	**17**	**18**
Mean	3.33	3.13	3.33	2.27	3.04	1.78	3.14
Item	**20 neg**	**22 neg**	**23**	**24**	**26**	**28 neg**	**Overall**
Mean	3.18	3.17	3.13	2.60	2.78	3.06	2.92

In addition to reliability between the items measuring each type of interest there is a significant correlation between students' scores for each type of interest (0.901, $p<0.01$) and in general students have a higher Situational Interest than Individual Interest which is in line with Hidi and Renninger's (2006) model.

Discussion of the results from Pilot 2

Section 1: Factors which affect the development of interest

The items in this section were included to assess what types of activities and opportunities students believe increase their interest in science lessons. It is not surprising that, on average, 'Carrying out practical work' was rated by students as having the largest positive effect on their interest in lessons (see Table 3.7). Perhaps more surprising is that 'Doing well in tests and assignments' was considered the second most interesting item, although there is quite high variance for this statement. The least interesting factors, which also have the highest variances of all items, are 'Doing mind teasers' and 'Doing drama to model scientific ideas'. These two activities will appeal to some and not others; however, the findings may be a result of students' lack of experience of these as some teachers do not use these techniques. It may also suggest that students are answering in terms of enjoyment rather than interest, focusing on the affective rather than cognitive impact of each activity.

Table 3.7 Pilot 2 Questionnaire: Section 1 – Rank order of items which increase interest in science lessons, based on mean score of student responses.

Item from Pilot Questionnaire: Section 1	**Rank of score**
Carrying out practical work	1
Doing well in tests or assignments	2
Doing something instead of the teacher just talking	3
Doing things which are related to my future career	4
Feeling I know what I should be doing	5
Learning information which is relevant to me	6
If the teacher is interested in the lesson	7
If I have a sense of achievement	8
Being able to pick the topic I will study	9
Doing tasks which will help me prepare for examinations	10
If I learn strange facts	11
Working in small groups	12
Using models to explain difficult theories	13
Learning the information in different ways	14
Using computers in our class	15
If I know something about the area of science we are studying	16
Watching the teacher demonstrate an experiment	17
Being able to present the information in a way I choose	18
If I can see the science we're learning is important in life	19
If it helps me understand how the world works	20
If I feel I have control over my work	21
Having the opportunity to explore the unknown	22
If I am supported in making good choices	23
If I already know something about the lesson topic	24
If I am given challenge	25
Developing a better understanding of scientific concepts	26
If I can see the links between new information and something I have previously learnt	27
If there is feedback on the choices I have made	28
Being given responsibility for my work and learning	29
If I have to think about the ideas	30
Having the opportunity to carry out independent studies	31
Having the opportunity to solve problems	32
Being able to discuss the topic with the rest of the class	33

Developing an understanding of the links between topics	34
Doing logic puzzles	35
Being able to discuss the topic with my teacher	36
Doing mind teasers	37
Doing drama to model scientific ideas	38

In order to understand how these items cluster, a factor analysis, with varimax rotation and Kaiser Normalization, was conducted. The factor analysis of Section 1 identified 10 factors; however, only the first four factors contained more than three items. This may be an artefact of a small sample size (n = 103) and that there were only 38 items, or an issue with the reliability of the items. Despite these issues, it was decided that a factor analysis would be appropriate for the main data set.

Section 2: The purpose of science education

This section aimed to establish what students believe to be the reasons for studying science between 14 and 16 years of age. Table 3.8 shows the descriptive statistics for the responses gained in the pilot study. The most strongly agreed with purpose is 'To prepare me to get a GCSE in science'. The majority of statements, on average, are 'mildly agreed with'; however, the statements relating to future careers and enjoyment show the greatest variance.

Table 3.8 Pilot 2 Questionnaire: Section 2 – Rank order of items regarding the purpose of science education, based on mean score of student responses.

Item from Pilot Questionnaire: Section 2	**Rank of Score**
To prepare me to get a GCSE in science	1
To learn scientific facts	2
To help me make decisions about scientific issues	3
To teach me things which will be useful for a job	4
To understand what science has achieved	5
To teach me how to use different types of scientific equipment	6
To help me understand current environmental issues	7
To learn some scientific theories	8
To explain how scientific investigations are done	9
To make me more interested in science	10
To prepare me for my future career	11
We all learn science because the country needs scientists	12
To teach me how to interpret scientific data	13

To give me confidence when making decisions	14
To learn how scientists investigate the world	15
To train people to be scientists	16
To interest me and make school enjoyable	17
To teach me about how to be healthy	18
To learn about different scientists	19

In order to understand how these items cluster, a factor analysis, with varimax rotation and Kaiser Normalization, was conducted. Eigenvalues equal to or greater than 1.00 were extracted. With regard to the 19 items used, orthogonal rotation of the items yielded four factors, accounting for 21.6%, 16.0%, 15.6% and 12.4% of the total variance respectively, a total of 65.6% of the of the total variance explained. To enhance the interpretability of the factors, only variables with factor loadings as follows were selected for inclusion in their respective factors: > 0.691 (factor 1), > 0.660 (factor 2), > 0.641 (factor 3) and > 0.609 (factor 4). Again, it was decided that a factor analysis would be an appropriate tool to apply to the main data set.

Section 3: Measuring an individual's level of interest

Section 3 of the questionnaire aimed to assess each student's interest in science, in terms of their Situational Interest, as it relates to science lessons in school, and their Individual Interest in science outside lessons.

Additional data collected in the survey allowed an initial investigation into the factors that may relate to a student's level of interest. Non-parametric tests were used to analyse these data as there is no reason to assume that the data collected were normally distributed. The set which a student was in displays a significant negative correlation with both Situational Interest (-0.466, $p<0.01$) and Individual Interest (-0.513, $p<0.01$), thus suggesting that there is relationship between which set a student has been placed in and their interest level. Different possible explanations for this are explored in the discussion of the main data set (see Chapter 4).

Items relating to who is responsible for developing interest were also included in this section. It is clear from Table 3.10 that the students felt, strongly and consistently, that the teacher should spark their interest and encourage their engagement even though there was also an acknowledgement that the students themselves can influence the level of interest they experience.

Table 3.9 Pilot 2 Questionnaire: Section 1 – Descriptive statistics for student responses to items relating to 'Who is responsible for interest?' (0=neutral; 1= agree; 2= strongly agree).

Item from Pilot Questionnaire: Section 3	**Mean Score**	**Standard Deviation**
I am more interested if I put more effort into the lesson	0.55	0.98
Teachers should make the lessons interesting	1.30	0.76

Section 4: Additional areas of interest

Question 4.4 asked students 'Do you think you should be given the choice of whether or not to study science in Years 10 and 11?'. Of the 94 students who responded to this question, 45% said that 'yes', although the reasons for this were varied as can be seen in Figure 3.4 below. A (small) majority of students felt that they should not be given the choice as to whether or not to study science in Years 10 and 11. The main reasons given for this (see Figure 3.5) centred around the importance of science for the future, either for different career paths or because the information one learns in science is useful. There is no significant difference in responses between the genders, and the set of the student had little influence on whether or not students felt they should be given a choice; however, significantly more set 1 students responded "no", they should not be given a choice than answered "yes" ($\chi^2 = 7.00$, df = 2, $p<0.01$).

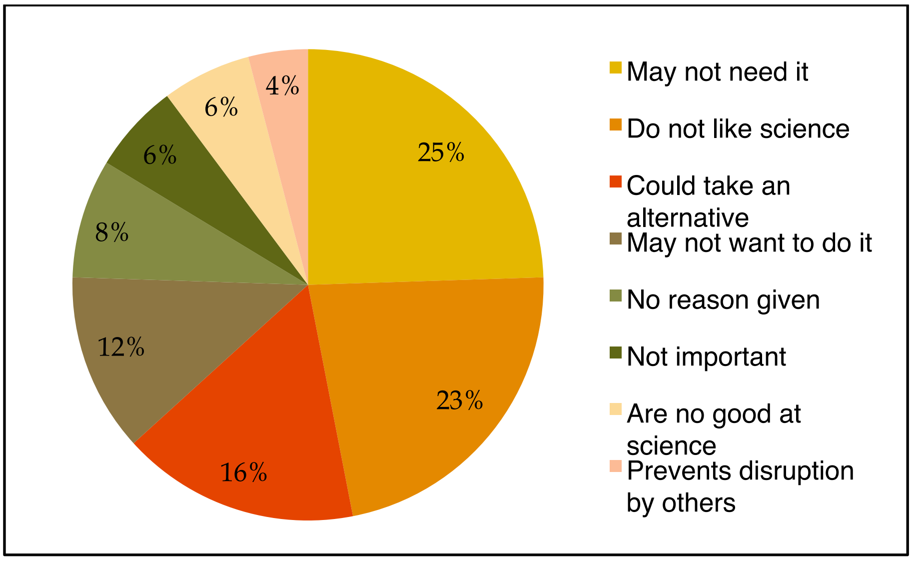


Figure 3.4 Pilot 2 Questionnaire: Section 4 – Reasons why students **should be** given a choice whether or not to study science at KS4.

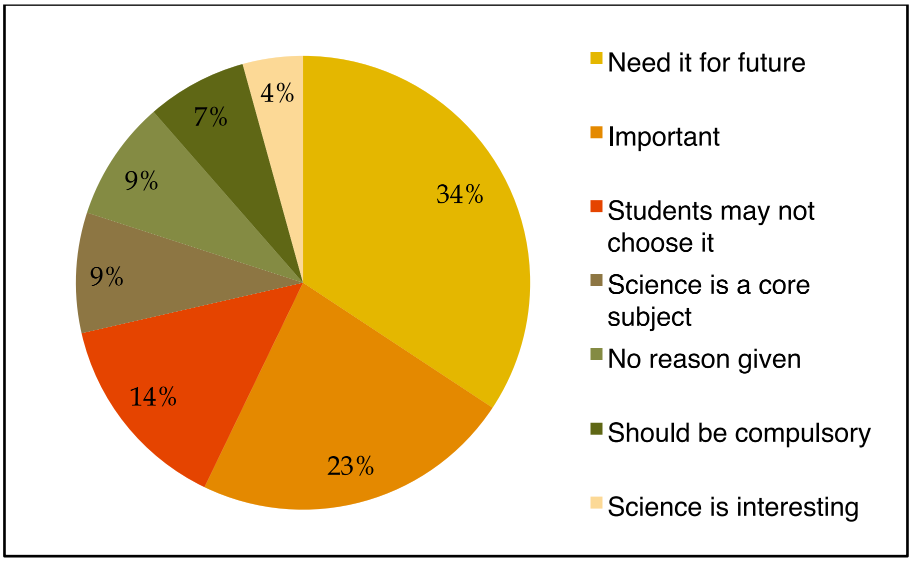


Figure 3.5 Pilot 2 Questionnaire: Section 4 – Reasons why students **should not be** given a choice whether or not to study science at KS4.

Analysis of pilot responses

It was concluded that the mean scores for each item from 'Section 1: Factors which affect the development of interest' and 'Section 2: Perceptions of the purpose of science' should be ranked to allow comparison between the relative importance students place on each item as this is ordinal data and therefore the rank order is more informative than the actual value given. Furthermore, a factor analysis was carried out to investigate if the items from these two sections could be grouped into a smaller number of underlying factors (Child, 2006) which influenced student interest or views on the purpose of studying science. Although there were minor issues with the factor analysis for Section 1 (see discussion below), it was decided that a factor analysis could be used for the results of Section 1 and Section 2.

Section 3 of the pilot questionnaire was used to ascertain both a Situational Interest score and an Individual Interest score for each student. These scores were then used to assess differences between groups of students, such as ability set, through comparison of mean scores and the standard errors for each group. This analysis method was adopted for the data collected using the student and teacher questionnaires.

The qualitative questions were included at the end of the questionnaire, in Section 4, to allow for the collection of rich data; however, it was deemed that the responses provided did not add any information which was pertinent to the research questions above and beyond the data collected from the first three sections of the questionnaire and the other data collection activities.

Student Questionnaires

The pilot questionnaire was amended, as outlined above, to produce three questionnaires for use in this investigation:

- Student Questionnaire 1 (Appendix 1) was based directly on the pilot questionnaire, containing all four sections
- Student Questionnaire 2 was a repeat of Sections 3 and 4 from Student Questionnaire 1.

As detailed in Sections 4.2 and 4.3, the data from the sections entitled ‘Factors which affect the development of interest’ and ‘Perceptions of the purpose of science’ were processed using a factor analysis and the student scores for ‘Measuring an individual’s level of interest’ were calculated to allow comparisons between groups and correlational analysis to take place.

Teacher Questionnaire

The Teacher Questionnaire was based upon Student Questionnaire 1. The question heading for Section 1 was modified to be:

> ‘How interesting do **you think your students** find each of the following activities or opportunities? Please place a tick in only one of the boxes on each row to indicate how interesting your students do, or would, find each of the following’

and the question heading for Section 2 was modified to:

> ‘To what extent do **you think that students may agree** with the following statements about the reasons why they learn science, particularly at Key Stage 4, in school?’.

The individual statements within these sections used the same wording as the statements within Student Questionnaire 1. In total, 11 teachers completed this questionnaire in June 2012, the same month as the students completed Questionnaire 1.

Stage 2: Case study of science lessons in School A

A case study methodology was used as the phenomenon; similarities and differences in the views of teachers and their students, cannot be separated out from the context, i.e. science lessons (Yin, 1981). Ethnographic methods, including observations and interviews along with field notes documenting personal reflections on interactions with individuals, were used to collect the data as I was fully integrated into the culture and community within School A.

The primary object of the case study was the experience of science lessons in School A. However, this evolved during the research process to focus more closely on two classes of students to investigate if it was possible to increase the interest levels these students have in both science lessons and science in general.

There are a number of reasons why the case study stage of the research was conducted in School A. As I had been working at School A for 10 years by July 2012 I had worked closely with the science teachers and students, developing positive professional relationships, which meant that they were more relaxed about the process and trusted that I would not be out to undermine them in any way. In addition, there was the obvious advantage of reducing time pressures as I was able to observe lessons and arrange meetings during non-contact time within the school day, or when suitable for the participants, which also made participation less onerous for those involved. The majority of the science teachers and all of the Year 9 (13 to 14 years old) students from School A also completed the questionnaires used for Stage 1 of the research and the analysis of their responses contributed towards shaping the data collection methods used for the case study. Finally, there was homogeneity of the sample in that all of the students followed the same curriculum and specification for the period of study under investigation, and all of the staff had been teaching the GCSE specification for the same period of time (it was introduced in September 2011). This commonality highlighted the different factors influencing the expectations held by staff and students as each lesson in the specification had clear objectives but a variety of ways of delivering them.

In addition to the brief outline of School A found in Box A (p. 83) further background is provided here. School A is a reasonably large school that has been on the same site and had the same buildings since 1949, although additional buildings have been added as the school intake has grown. When the school first opened it was literally divided into two, forming the County Grammar School for Boys and the County Grammar School for Girls. During 1978 the dividing wall was removed and the school became a co-educational comprehensive school, no longer requiring students to pass the 11+

examination in order to be admitted. Despite the fact that the school had been a comprehensive school for 24 years when I was first employed there, it was common to hear staff using the phrases 'we used to be a grammar school' and 'the [School A] way' when referring the expectations that were held regards staff and students. This, in part, may have been due to a number of staff having been at the school from before the transition from a grammar school to a comprehensive school, with the last member of staff who had taught in the grammar school only retiring in 2013.

During the period of this research, there were 13 members of staff in the science department at School A, all of whom held a good degree (2:1 or higher) in their subject specialism. There was a reasonably equal gender split, both overall and within the three subject areas of biology, chemistry and physics. Although School A could be considered a typical high achieving mixed, comprehensive secondary school the student responses to the questionnaire (see Section 5.1) were significantly different to the responses given by the students attending the other three schools. In particular, the findings from the Student Questionnaire 1 indicated that students attending School A had lower levels of interest in learning Science at GCSE level. Although this may reduce the extent to which the case study findings can be generalised to other schools it suggests that there is a need to investigate, in more depth, the factors which influence student interest, and whether or not it is possible to increase their interest over the two years of GCSE study.

<u>Sample of participants</u>

Volunteer sampling was used to select teachers for Stage 2 of the research as it required a substantial input in terms of time and effort from the participants. Although this may have affected the population validity of the sample (people who volunteer may tend to have slightly different personality traits from those who do not, e.g. highly motivated) the quality of the data is improved as the participants wanted to engage with the processes and felt they gained something from their involvement. In addition, the participants were well known, allowing individuals' characteristics to be taken into account when conducting the analysis. All science teachers who were employed by School A in September 2012 were invited to participate. The final sample considered of 3 members of staff: Mr T, a Newly Qualified Biology Teacher in his first year of teaching (left School A in July 2013 to work at another 11-18 school); Mr S, a Biology Teacher who had around 10 years teaching experience at the start of the data collection and Mrs M, a Chemistry specialist who entered teaching around five years before the start of this study, after working in industry for a number of years. Mr S and Mrs M were still working at School A by the end of the data collection period in July 2014. All three teacher participants had recently been involved in academic study. Mr T had completed his PGCE the summer before joining the school as an NQT in September 2012. Mr S and Mrs M had, during the previous year, both completed one module at Masters Level through a scheme run by the school in partnership with a local university. The school provided funding to pay for this module and all of the tutorials took place within school, led by a visiting lecturer from the university. None of the teachers who completed this first module chose to continue to complete the full Masters Level qualification as there was no available funding for the final two years of study and they would have been required to travel to the university for evening and weekend classes. However, a number of teachers were then interested in continuing to engage with academic research and use this to inform their teaching; thus, Mr S and Mrs M agreed to participate in my research.

The student participants were determined by which teachers had agreed to participate in Stage 2 due to class allocations when the school timetable was written in the Summer term of 2012. The students will be referred with regards the science class they were in for the two years of GCSE Science study. Class 1 and Class 1b were both groups studying Separate Science GCSEs, therefore they had 15 hours of contact time with science teachers for each timetabled fortnight. Class 1 were taught by Mr T for the first year of Key Stage 4 (Year 10) and by myself for the second year (Year 11) and Mr S taught Class 1b for both years of study. These students self-selected to complete the Separate Science course and are in the top ability group of the year. The students in Class 2 and Class 4 all completed Science GCSE during their first year of study and Additional Science GCSE during Year 11. Both of these courses combined elements of biology, chemistry and physics and were taught in nine hours each fortnight. Mrs M and I taught Class 2 the biology and chemistry content respectively over the two years and Mrs M also taught Class 4 for two years.

<u>Data collection activities</u>

Figure 3.6 provides a timeline of the data collection activities which occurred during the 21 months of Stage 2. The first column states the date the activity took place, the second column states what the activity was and the third and fourth columns indicate which classes of students and teachers were involved respectively. Where the student participants were involved in focus group interviews the class number has been included to indicate which group of students the sample was drawn from.

Date	Activity	Student participants	Teacher participants
18 Oct 2012	Inheritance	Class 2	
09 Nov 2012	Teacher focus group		Mrs M, Mr T, Mr S
07 Dec 2012	Lesson observation	Class 1	Mr T
13 Dec 2012	Reflective discussion		Mr T
13 Dec 2012	Lesson observation	Class 2	Mrs M
07 Feb 2013	Student focus group	From Class 1 & Class 2	
15 Feb 2013	Self-observation Smoking/disease	Class 2	

26 Mar 2013	Reflective discussion		Mrs M
10 May 2013	Teacher focus group		Mrs M, Mr T, Mr S
07 Jun 2013	Teaching and Learning group		Mrs M, Mr T
10 Jun 2013 - 22 Jul 2013	T&L focus for lessons: Personal endeavour	Class 1 Class 2, Class 4	Mr T Mrs M
10 Jun 2013	Self-observation Cell structure	Class 2	
11 Jun 2013	Self-observation Microscopes	Class 2	
14 Jun 2013	Teaching and Learning group		Mrs M, Mr T
19 Jun 2013	Self-observation Modelling DNA	Class 2	
21 Jun 2013	Teaching and Learning group		Mrs M, (Mrs B)
28 Jun 2013	Teaching and Learning group		Mrs M
02 Jul 2013	Lesson observation	Class 4	Mrs M
04 Jul 2013	Lesson observation	Class 2	Mrs M
22 Jul 2013	Reflective discussion		Mr T
22 Jul 2013	Self-observation Summary posters	Class 2	
20 Sept 2013	Teaching and Learning group		Mrs M, Mr S, (Miss N)
01 Nov 2013 -16 Feb 2014	T&L focus for lessons: Purpose Factors & *Exploring science*	Class 1 Class 1b Class 2	Mr S Mrs M
02 Dec 2013	Self-observation Controlled Assessment Task	Class 1	
12 Dec 2013	Lesson observation	Class 2	Mrs M
13 Dec 2013	Reflective discussion		Mrs M
12 Dec 2013	Lesson observation	Class 1b	Mr S
13 Dec 2013	Reflective discussion		Mr S
06 Jan 2014	Self-observation: Feedback	Class 1	
24 Feb 2014	Self-observation: Biological Rhythms		
25 Mar 2014	Student focus group	From Class 1 & Class 2	
01 May 2014	Student focus group	From Class 1 & Class 2	
09 May 2014	Teaching and Learning group		Mrs M
06 Jun 2014	Teaching and Learning group		Mrs M, (Mrs V)

12 Jun 2014	Teaching and Learning group		Mrs M, (Mrs V)
22 Jul 2014	Reflective discussion		Mr T

Figure 3.6 The data collection events for Stage 2 of this thesis, including when each activity occurred and which participants were involved. Teachers in brackets are from other departments within the school who asked to join the Teaching and Learning Group meetings.

Lesson observations

Lesson observations were either conducted as 'self' observations where a lesson plan was written prior to teaching, with specific reference to *Purpose Factors* and *Interest Factors,* and the lesson was then reflected upon as soon after as possible. The lesson plan template and the record form completed after the lesson can be found in Appendix 5 and 6 respectively. In essence I acted as a participant observer through a clear engagement with the 'social and "symbolic" world through learning their social conventions and habits, their used of language and non-verbal communication, and so on' (Robson, 2011, p. 319). This participation was entirely genuine as a result of the working, as a biology/science teacher and conducting smaller research projects, within the same school for eight years prior to commencing this research. This close engagement with all aspects of this 'social world' provided a strong foundation for valid interpretation of observation data. In addition to the pre-planned self-observations detailed field notes were also made in order to record particularly poignant teacher-student or student-student exchanges throughout the 21 months (September 2012 to July 2013 and September 2013 to June 2014) of working with the student participants.

When someone else was teaching the lesson the observation was carried out in an unstructured form as the purpose was to explore and develop understanding of student and teacher behaviours in lessons and how these may influence the levels of interest demonstrated by the students (Robson, 2011). A narrative account, which recorded the researcher's thoughts at the time along with the activities of the participants of each lesson, was typed during each observation period. Where appropriate, direct quotations from participants were also captured. Immediately after the observation had taken place the narrative account was scrutinised and information was transferred onto a Lesson Observation Record form (see Appendix 5) to allow more in depth consideration of the data in light of the research questions and the questionnaire findings. The role of the researcher during these observations shifted from 'participant as observer' to 'observer as participant' (Cohen, Manion and Morrison, 2011, p. 457) as the nature of the participation changed from that of class teacher to an observer who is viewed to be embedded in the school culture and environment since teachers observing lessons is a common activity. During these observations I was positioned towards the rear of the room and off to one side to allow a view of the entire room and all students, without having to move significantly. I did not initiate conversations with any of the participants, and if students spoke to me during the lesson I quickly, and politely, asked them to return their focus to the teacher or the task they had been asked to complete. A small number of times students did ask for help on how to complete a specific task and in these instances I suggested that they read the information the teacher had provided, or asked the teacher for help, to avoid adopting a teaching role in the lesson.

An advantage of carrying out these observations was the ability to increase the validity of the data as it is less vulnerable to social desirability bias than survey responses (Robson, 2011) and allowed discussion of any variation between the students' and teachers' response to the questionnaire and their behaviour during lessons. Informal observations were used to facilitate the capture of the complexity of behaviours and interactions (Robson, 2011) involved in lessons. The Hawthorne effect and reactivity (Robson, 2011) are obvious concerns when conducting observations and due to the nature of the observations conducted here there was an unavoidable impact on the behaviour of the participants, both teachers and students. However, part of the aim of this research was to acknowledge that the teachers may alter their teaching as a result of the focus group interviews and teaching and learning group discussions and then to explore these changes and any impact they may have. In addition to making the impact of an observer more explicit, the situation is a legitimate one as all of the participants in the second stage of this study were used to having their lessons observed for a number of purposes.

A further concern about the use of observations and interviews was that it could have been onerous and time consuming for the participants. To manage these concerns both the teachers and students were asked if they would be willing to be observed or take part in the reflective discussion and focus group interviews before each event and these were arranged at times to suit the participants. The teachers who volunteered to participate in this research were invested in the process and valued it as part of their professional development and therefore were comfortable with the time commitments required as a result of their participation. In addition to this, the teachers who agreed to be involved with this research were motivated and saw value in terms of developing the quality of their classroom practice.

Focus group interviews

Focus group interviews were carried out with either groups of teachers or with groups of students as per the schedule in Figure 3.6. These were conducted with groups of between 3 and 5 participants at a time to allow discussions to develop and therefore increase the range of responses (Watts and Ebbutt, 1987) and as such the participants were encouraged to discuss the responses between themselves, rather than giving individual responses within a group setting (Cohen, Manion and Morrison, 2011). In addition, there were instances, particularly during the student focus groups where participants ‘cross-checked’ each others’ responses and provided additional points to either disagree with, or clarify, what was being said (Arksey and Knight, 1999).

These interviews were unstructured in form. The questions were all direct, based either upon questionnaire responses, specific episodes from lessons or participants’ previous answers and as such, although the theme of each focus group and some key questions were written prior to the interviews, not all questions could be anticipated. This form of questioning led to unstructured responses from the participants to allow them to express their answer in the way they wanted to and avoided participants agreeing with a set of predetermined answers (Tuckman, 1999).

In order to manage the dynamics of the interviews and emotional factors which may influence participants (Cohen, Manion and Morrison, 2011) the teacher interviews were conducted in a school meeting room; this reduced the risk of interruptions from other staff or students and framed the session as different from other meetings or discussions. Student interviews, however, were conducted in their biology teaching laboratory in order to help them feel relaxed and comfortable by being in familiar surroundings. Through careful consideration of the interview as “a social encounter” (Cohen, Manion and Morrison, 2011, p. 242) the focus group interviews conducted fulfilled many of the ‘quality criteria’ outlined by Brinkmann and Kvale (2015): the participants provided rich, relevant, specific and sometimes spontaneous answers; the questions were kept relatively short in comparison to the length of the answers; the answers were interpreted and followed up throughout the interviews and attempts were made to verify my interpretations of the participants’ answers during the course of the interview.

Reflective discussions and the Teaching and Learning Group

Reflective discussions took place between a teacher and myself, usually closely following a lesson observation. The purpose of these was to develop an understanding of the teacher's views of the lesson with a particular focus on the Purpose Factors and Interest Factors present and how these were communicated. These discussions, along with the Teaching and Learning Group discussions (discussed below), although informal, followed a similar pattern to the use of coaching for professional development.

Coaching has been used in schools for professional development purposes since the 1980s, in part to address the low rate of learning transfer from professional courses into the classroom (Showers and Joyce, 1996). There is empirical evidence (Showers and Joyce, 1996) that peer coaching supports teachers in collaboratively developing skills which allow them to implement change in the classroom, and thus improve student experiences. However, these positive effects are only seen when the peer coaching has a theoretical underpinning and is focused on "the study of teaching and curriculum" (Showers and Joyce, 1996, p1). On a practical impact level, teachers involved in successful peer coaching appear to show greater adaptability to the use of new strategies for longer, over time, as well as practising their new skills more frequently (Rhodes and Beneicke, 2002).

Coaching has been given numerous descriptive prefixes, some of which are merely alternative terms for the same thing and some which reflect alternative foci and purposes for coaching. Two main distinctions can be drawn: coaching which aims to improve existing practice, e.g. cognitive coaching, and coaching which focuses on innovations in curriculum and teaching, e.g. peer coaching (Showers and Joyce, 1996). The approach adopted in this study fitted somewhere in-between these two; teachers were supported in developing their current practice with the guidance of a theoretical understanding of ‘interest’ and of student views which I had developed. The changes in practice were therefore informed through research, both background reading and data collected. In this way the sessions fell part way between coaching and mentoring.

Much of the writing about what it means to be a reflective practitioner in teaching is based upon the work by Schön (1987) who described three states: knowing-in-action; reflection-in-action; reflection-on-action. All skilled teachers who can perform their roles without apparent effort or thought draw on the knowledge they have through knowing-in-action. Reflection-in-action, however, is the act of reflecting upon practice whilst carrying out the action. Reflecting during lessons enables teachers to “adjust their actions to the continuing flux of the classroom environment” (Barnett and Hodson, 2001, p. 430). Although some researchers have put forward the view that there is no time to be truly reflective in lessons (van Manen, 1995), others have interpreted reflection-in-action to mean the ability of a teacher to “be flexible in order to practise competently, in response to the contingencies of the moment” (Heilbronn, 2008b, p. 51). Finally, ‘reflection-on-action’ is the reflection which takes place after an action as occurred. The purpose of reflection-on-action is “teachers’ thoughtful consideration and retrospective analysis of their performance in order to gain knowledge from experience” (Leitch and Day, 2000, p. 180).

A key issue to address is how much independent reflection-on-action takes place in the day-to-day practice of teachers, given the pressures of teaching a full timetable and all that entails in terms of planning, marking, meetings etc. Sustained reflective practice is often lost as teachers move through their careers and much of the discussion about becoming a ‘reflective practitioner’ remains largely rooted in initial teacher training or the early years of a career. One way to address this issue is through the development of ‘practical judgement’ (Heilbronn, 2008a; Heilbronn, 2011). Practical judgement is the ability to respond to the ever-changing classroom environment in a thoughtful and flexible manner whilst being able to combine theoretical knowledge with the body of knowledge gathered through personal experience. Practical judgement can be developed through engaging with educational theory and research as well as holding professional dialogues with others. This engagement will allow teachers to continue to develop their knowledge over time and in a context-specific way (Yandell, 2011). By working with peers, via coaching or mentoring, to structure the reflection activities, teachers can address not only the cognitive aspects but also the social and affective dimensions required for professional development to be effective.

The processes of coaching and mentoring can be used to move those new to the profession from what Lave and Wenger describe as legitimate peripheral participation to full participation in a community of practice (Yandell, 2011). However, this could be taken to imply that those who are more established in their teaching careers are full participants of this community and therefore the obvious question to ask is 'what does it mean to be a full participant in a community of practice?'. Continuing engagement with research through reading or primary studies encourages teachers to have a broad and ever developing view of teaching, pedagogy and new initiatives or strategies which may enhance their own classroom practice. If this was extended beyond an individual teacher's practice it could prove to be a powerful tool in creating a strong and dedicated community of practice (Lave and Wenger, 2005) both within schools, for example, working across the curriculum, and beyond the boundaries of schools, for example though involvement with other institutions. In the context of this study the on-going engagement with theoretical developments as well as sharing expertise and reflections with other participants in this community was developed through the Teaching and Learning Group. This group evolved into what Campbell, McNamara and Gilroy (2004) describe as a critical friendship group, where teachers supported each other but at the same time felt comfortable enough to offer a constructive critique of others' ideas. At no time did this group become a "critical community" which "had a 'validation' type role in the research project" (Campbell, McNamara and Gilroy, 2004, p. 118).

Due to constraints of the school day and other commitments it was not possible to develop a strict and structured cycle of coaching through observation- discussion-reflection which occurred on a regular basis throughout the two years of data collection. During the second teacher focus group interview (10 May 2012), Mrs M proposed that we meet more frequently to allow more time for reflection on strategies and discussion of the research; those attending these meetings were referred to as members of the Teaching and Learning Group. However, during a teacher focus group interview (10 May 2013) Mrs M proposed that the frequency of meetings was increased to allow further discussions to take place with a more in-depth reflection upon specific lessons or ways of teaching particular content or groups of students. As a result of this we developed the Teaching and Learning Group, which met informally during lunch-time breaks. This expanded over the two years of data collection to include teachers, from other subject areas (english, psychology and drama) who heard about group discussions and asked if they could attend.

Working to increase student interest

Very early on in the research process, it became clear that the teacher participants wanted to engage more thoroughly with the research and further consider the impact of the Interest and Purpose Factors generated in Stage 1 of the study. As such, we agreed to investigate how to increase student interest as a group.

Figure 3.7 outlines the way in which we did this. Due to the complex nature of interest and the wide range of factors, both in and out of the classroom, I decided that this aspect of the research should be conducted through rigorous reflective practice – reflecting on the data collected during Stage 1 of the research and considering how it related to classroom practice – as opposed to an intervention study focusing on one specific strategy.

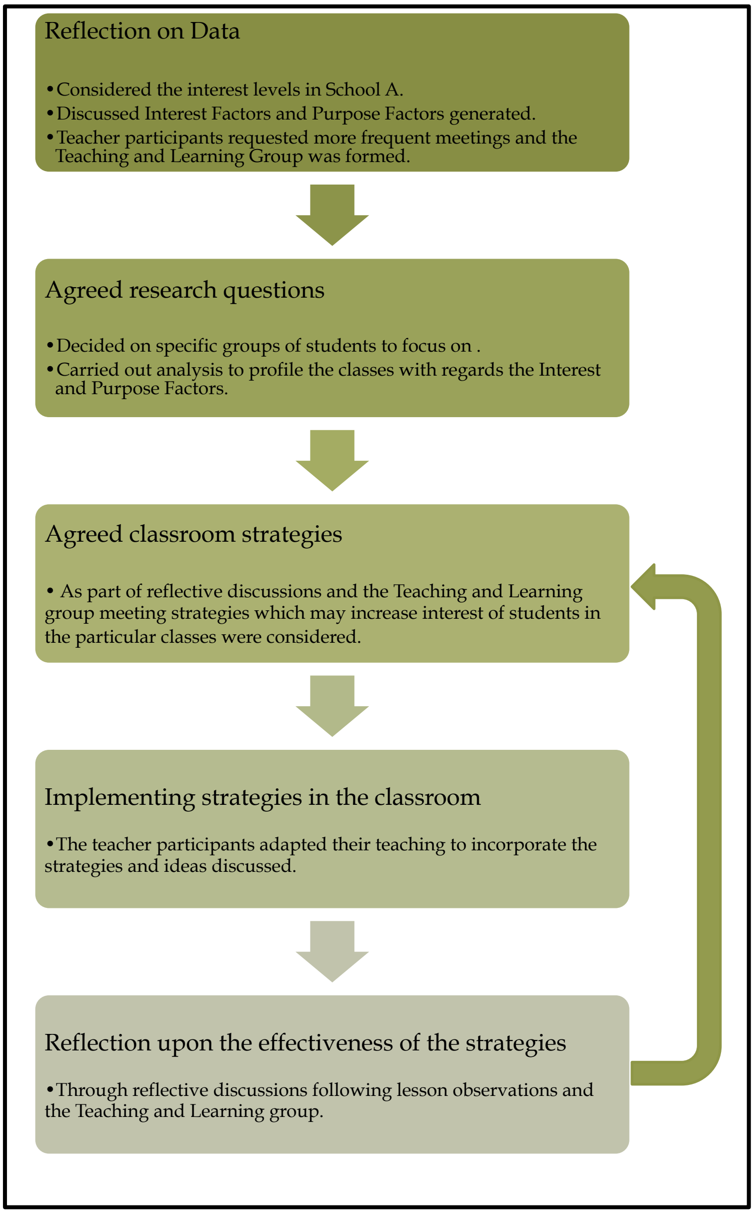


Figure 3.7 An outline of teacher participant involvement in Stage 2 of the method.

I shared the findings from Student Questionnaire 1 with the teacher participants during the first Teacher focus group interview (9 Nov 2012). All of the teacher participants were particularly interested in the stark differences between the students from School A and the students from the other schools. The issues of why these students had such low levels of interest and whether or not they could be increased formed part of the discussion that followed.

Although there was the opportunity to observe four different classes (1, 1b, 2 and 4), it was agreed that we would focus on two specific classes of students (Class 1 and Class 2) as these classes were taught by two of the teachers involved (me and one other) and the other classes were only taught by one participating teacher. The grouping of students into different classes at School A is based on a number of different factors. All students have the opportunity to study the separate sciences at GCSE as one of their option choices. Those students who choose not to study the separate science GCSEs are then set, based on a combination of their performance in internal examinations taken towards the end of Key Stage 3 and teacher judgments. During the two years of GCSE study each class has one specialist teacher for each of the three science subjects, unless there are reasons that this is not possible such as teachers leaving the school. As such I taught Class 1 for the second year of their GCSE Biology course, and Class 2 for both years of the course, covering Science GCSE and Additional Science GCSE. Mr T taught biology to Class 1 for the first year of the GCSE Biology course before moving to another school and Mrs M delivered the chemistry units to Class 2 for the entirety of the Science and Additional Science courses.

Class 1 consisted of 29 students, 14 girls and 15 boys, who were all in ability set 1 at the time they completed Student Questionnaire 1 and all elected to study separate science GCSEs; three qualifications, one in each of biology, chemistry and physics. The distribution of students' minimum target GCSE grades (MTG), based on FFT20 predictors, was three students with a target of an A*, 17 had a target of A and eight had a target of B. Students were also asked to set themselves a student target grade (STG), and although they were encouraged to have aspirational STGs, the students in this class chose to keep these the same as their MTGs.

Class 2 consisted of 27 students, 13 girls and 14 boys, all of whom were in ability sets 2 or 3 when they completed Student Questionnaire 1. These students did not choose to study separate science GCSEs and therefore completed two qualifications: GCSE Science and GCSE Additional Science. The students had a minimum target GCSE grade (MTG) of a B or a C, based on FFT20 predictors. I discussed the setting of Student Target Grades (STGs) with this class towards the end of October 2012, in line with the school directions, and around half of the students set their STG one or two grades higher than their MTG. Students' decisions about their STGs appeared to be based on their prior attainment and the level of confidence they had in their ability and understanding. In some cases students also asked their friends, or me, what grade should be chosen, and clearly considered these responses before settling on a grade.

Each of the teacher participants agreed to take part in a reflective discussion with me following each of the observed lessons, to agree strategies which could be employed to try to increase the interest of the students in those classes. A range of teaching strategies was developed after collaborative consideration of the Interest Factors and Purpose Factors generated from this research (See Sections 4.2 and 4.3 respectfully for discussion of these factors). The general strategies were then adopted by the teacher participants and incorporated into their lessons where possible and appropriate; with at least one strategy from the list being used each lesson with Class 1 and Class 2. A summary of the general strategies used can be found in Table 3.10 and a more detailed discussion of some of these strategies in included in Chapter 6.

Table 3.10 A summary of the teaching strategies used in Stage 2 of the study.

Teaching Strategy	**Interest Factor addressed**	**Purpose Factor addressed**
Increasing use of short video clips to support teaching	Learning from others	
Jigsaw-grouping to develop and share knowledge		
Grouping students to work on specific aspects of practice-controlled assessments		
Varying how students are grouped depending on the task, e.g. teacher directed / student choice		
Providing students with options with regards to which questions they will answer: these varied based on level of challenge or the (aspect of the) topic addressed	Control	
Introducing and encouraging flexibility of presentation of information, e.g. diagram or text, and allowing students to decide which to use.		
Questioning students to elicit clear and explicit reference to prior learning	Personal endeavour	
Being explicit about learning outcomes / success criteria at some point during the lesson		Professional relevance
Setting up and adding to a 'favourite word wall'		Personal relevance
Providing individual feedback to each student		
Increasing the range of activity types each lesson / series of lessons rather than using the same teaching style throughout		

Being explicit about the relevance of the content		
Four statement plenary: I already knew …, I now know …, I would like to know …, This is important because …		Personal and Social relevance
Periodic table bingo	Puzzles	
Guess the number quiz		
Making and using a variety of models, e.g. DNA from sweets, chromosomes from plasticine to show mitosis, 'moly-mod' molecules	Modelling	
Role-play / models involving student movement, e.g. diffusion of gases, movement of molecules in circulation, atomic structure and electron shells		
Reference to specific pieces of research	Exploring science	Social relevance
References to famous scientist (discussion / posters)		Social and Personal relevance
Increased use of open discussions / allowing time for students to ask questions around the topic		Personal relevance
Students encouraged to write questions on Post-it notes to hand in and be addressed in subsequent lessons		
Plenary getting students to finish the sentence 'I would like to know . . .'		

Processing and analysis of data

Coding the qualitative data

In order to keep the data collection focused on the subject of the thesis, namely interest, all data collection episodes were conducted with the *Interest* and *Purpose Factors* in mind. For example, when planning lessons for self-observations, careful consideration was give to which of the strategies (Table 3.10) would be used within the lesson. Similarly, the use of these strategies, and how students responded to them, was a key focus when conducting lesson observations of other teachers. However, to avoid missing other factors which may increase student interest, a narrative account was written during the observation, noting a wide range of activities and behaviours from both students and the teacher. Each account was then considered, alongside the rest of the data, and reflected upon in order to consider if any other key factors relating to interest or purpose were present.

<u>Explanation of transcription codes</u>

All quotations from the focus group interviews have been transcribed directly from audio recordings of the interviews. They have been annotated using the codes taken from Dressler and Kreuz (2000) which can be found in Table 3.11.

Table 3.11 Transcription codes used for presenting data from interviews and lesson observations, where appropriate. Taken from Dressler and Kreuz (2000).

Code	**What the code represents**
?	Rising intonation at end of sentence
.	Falling intonation at end of sentence
/ \	Rising and falling intonation within text
,	Continuing intonation (like in a list)
CAPS	Stress or emphasis in the text
…	Short un-timed pause
> <	Talk spoken rapidly
:	Lengthened Syllable
-	Word cut-off (Abrupt self-termination)
=	Latched talk (no gap between two speakers)
[]	Overlap Speech
ITALICS	Spoken loudly
.h	Inward breath
(( ))	Paralinguistic behaviour
( )	Unclear or unintelligible speech

Where quotations involve multiple speakers the codes ‘S1, S2, S3 etc.’ are used to denote different students speaking. The numbers represent order of speaking rather than specific students. The teachers, however, are referred to as Miss M, Mr T and Mr S to indicate who is speaking.

All quotations have been transcribed verbatim except where the participants have named specific people. To preserve confidentiality and privacy the people named are referred to as ‘Miss X / Mr Y etc.’ if they are a teacher or other member of school staff and 'Student 1 / Student 2 etc.' to indicate a student has been named.

The quotations selected are representative of the views of the students interviewed and attempts have been made to report differing opinions where presented by students. However, there were few instances where students communicated disagreement with something one of their peers had said.

Where comments are included from lesson observations they are presented as the notes were taken on the day. Text in italics represents my thoughts and commentary noted at the time of data collection, rather than a specific event which had been observed. Direct quotations from lesson observations were written down verbatim at the time they were said and if this was not possible the comment was paraphrased at the soonest opportunity and is therefore not presented at a direct quotation.

General issues surrounding collection and analysis

It must be acknowledged that the students were taught by at least three different science teachers: specialists in biology, chemistry and physics for the two years of the course. In addition to this, the students will have been taught science by anywhere between one and eight different science teachers in their previous years in secondary school. Therefore, the focus will be on an individual teacher and the class as a unit of study over time.

3.4 Ethical considerations

The research is school-based and therefore was carried out in line with the ethical guidelines laid down the British Educational Research Association (2011). There were two groups of participants for this research: secondary science teachers (n = 11) and students (n = 475). The students were all nearing the end of Year 9, therefore were aged 13 or 14 when the research commenced. All participants were involved in Stage 1, the survey component, then three teachers and the students in their classes, around 75, comprised the sample of participants in the Stage 2 case study. I was the only researcher interviewing the students and as I work as a teacher I have already been subject to a full Criminal Records Bureau check.

It is hoped that there was a direct and immediate benefit for all of the participants involved in Stage 2 as this was based around the teachers reflecting and developing their practice in order to spark and maintain the interest of their students. The skills and reflective practices developed with the teachers involved in the discussions should serve them well to continue effective self-evaluation. In the future this work may be of benefit to other teachers who are concerned with the construct of interest and how it relates to secondary science education.

There were relatively few risks to participants or myself as the researcher. The aim of the research was to empower teachers and develop teaching and learning for the students; and in fulfilling this aim it was a positive experience for all involved. There may have been a risk that the teachers being observed felt vulnerable or exposed as a result of discussing their lessons, having the students discuss the lessons, or by having a colleague in their classroom. This was minimised through a number of safeguards including asking for teachers to volunteer to take part, and reminding them they have the right to withdraw at any time. In addition, coaching discussions, as well as lesson observations, are common practice within the school and so teachers and students are aware of the objectives and stages of these types of processes for professional development purposes. I have been involved in coaching staff for a number of years and have high professional integrity which worked to reduce any conflict which may have resulted from my having multiple roles as researcher, teacher and colleague. Furthermore, the goals of the reflective discussions were framed by the research questions but led by the teachers themselves, as is the nature of coaching. In addition, I set out a protocol for the observations and discussions which was agreed with the teacher participants before commencing. This was based on the current school policy with regards coaching and professional development and highlighted the rights and responsibilities of all involved. No data which could be considered 'sensitive' under the Data Protection Act 1998 were collected.

It was acknowledged that the participants were being asked to undergo additional lesson observations and meetings as a result of the second stage of data collection. To ease this burden, it was agreed with the school's professional development co-ordinator that the teachers were able to use these observations as their required coaching development which formed part of the whole school professional development programme at the time. As stated above, the teachers involved were volunteers and had the commitment required of them explained at the outset. Feedback from the teachers involved indicated that the process was seen as a positive experience and an opportunity to engage in quality professional development and that this benefit out-weighed the additional time costs.

Informed consent was gained from all participants at each stage of the research and there was no need for any deception. The questionnaires included a short introduction, which emphasised that it was not compulsory, and consent was inferred if the participants continue to completed the questionnaire. At the start of Stage 2, participants signed a consent form which outlined the aims of the project, the methods which were to be used and the rights of the participants. The details of the project were explained to all science teachers in School A and were reiterated before the volunteers confirmed that they would be willing to take part, which ensured their consent was fully informed. The student participants for Stage 2 were determined as a result of being in one of the classes taught by the volunteer teachers. School A, where the case studies were conducted, was supportive of the research and happy for the students, and teachers, to participate. In line with school policy, a letter informing them of the procedure and purpose of the research was sent to parents or guardians of all student participants. It asked that they contact the school if they required further information or did not want their child to be involved in any aspect of the project. None of the parents / guardians formally contacted the school, nor did any withdraw their child, or their child's data, from the study. I worked closely with the school and the Assistant Head teachers who were responsible for safeguarding, pastoral matters and professional development throughout research to ensure the school policies was adhered to appropriately.

No monetary incentive was offered to the participants to take part in the study. The teachers who volunteered to be cases may have seen this as a chance to engage in professional development which they may otherwise not have had access to, but this only served to enrich the quality of research, rather than lead to desirability biases or demand characteristics. At the time of the research I was not in a position of responsibility within the school staffing structure, which directly impacted the teacher participants and therefore was not in a position to offer work related incentives, nor could participants presume this to have been the case.

The survey responses are treated as confidential and pseudonyms are used throughout the thesis. Confidentiality will also be upheld for the other data collection methods. Participants' involvement in the research was not discussed outside of the data collection episodes and never with other members of staff. Similarly, I did not discuss any content from the lesson observations or reflective discussions with anyone other than the teacher involved, although at times the participants chose to discuss their involvement with others. One of the participants invited the other members of staff to the teaching and learning group discussions. Questionnaire and interview data from specific groups of students was used in the planning sessions and reflective discussions with the teachers. Student confidentiality was upheld for this and all responses were summarised. The teacher participants did not know which students were involved in interviews or focus groups; however, I had little control over the students discussing this themselves. Anonymity was not provided for all participants to allow tracking of participants over time as well as being able to compare teachers' responses to those of their students. With regards to data storage, I complied with all legal requirements, set out in the Data Protection Act (1998), which relate to the storage and use of personal data. In addition, each participant was given the opportunity to read the parts of the drafts and the final thesis which referred to them individually before it was submitted. Participants were provided with the opportunity to withdraw their data from the research as well as having the right to withdraw from the research at any time.

The findings of this research were made available to each of the schools involved. The participants had access to the findings as the research progressed, at times explicitly, such as when responses were examined during focus group and reflective discussions, and at times implicitly since much of the focus was on reflection and development of teaching to increase student interest. At the conclusion of the data collection all participants, teachers and students, were debriefed face to face.

This research was, in a sense, sponsored by the school where I am employed as they enabled me to access to participants and allowed me to carryout research whilst working there. As expected by the British Education Research Association (2011), copies of the BERA research guidelines and the ethical considerations submitted to the ethics committee were sent to the Head Teacher and the appropriate Assistant Head Teachers and they were informed of all aspects of the work at each stage, including the proposal and regular updates of progress. A detailed justification of the methods used for data collection and a discussion of the reliability, validity and generalizability of the findings were made available to the school.

The findings from both Stage 1 and Stage 2 data collection activities are presented and discussed in the next two chapters. Chapter 4 presents students' understanding of interest and their interest levels at the start of this study, along with the key factors which were identified as increasing student interest in, and being the purpose of, learning science. Chapter 5 goes on to examine the differences between groups of students, specifically those that relate to school, gender and ability set, with regards to the three core themes discussed in Chapter 4: interest levels; agreement with Interest Factors and agreement with Purpose Factors. In addition, the students' responses to the three themes are compared with those of the teachers. The final section of Chapter 5 explores the possible reasons for the different responses.

Chapter 4: The Factors which students say influence interest level

This chapter explores the factors which students say influence their levels of interest by drawing on the findings from Student Questionnaire 1 (Appendix 1) which was administered in Stage 1 of the study to assess students' levels of interest, what they believed increased their interest in learning science and what they considered to be the purpose of learning science between 14 and 16 years of age. Students were asked to select, using a Likert scale, the extent to which they agreed or disagreed with the statements offered. To enable a quantitative analysis of student responses the options for each statement were scored as follows:

- -2 = strongly disagree
- -1 = disagree
- 0 = neutral
- +1 = agree
- +2 = strongly agree.

The initial quantitative analysis was carried out prior to Stage 2 of the study in order to inform the nature of the qualitative data collection activities in Stage 2. However, in order to provide a full consideration of the perceptions of students as to the factors that influence their interest levels, this chapter draws on both the quantitative data from Stage 1 and the qualitative material from Stage 2. The overall levels of student interest and their interpretation of what the term 'interest' means are presented first (Section 4.1), followed in turn by the analyses of the factors which students' consider influence their interest in science (Section 4.2) and their views as to the purpose of learning science (Section 4.3). Having presented the findings, a series of discussions explore the relationships between the various elements and where the findings from this study sit with regards to previous research.

4.1 Students' levels, and understanding, of interest

As discussed in Section 2.2, it is generally accepted that there are two types of interest, referred to by Hidi and Renninger (2006) as Situational Interest, a short-lived response to an individual's interaction with an artefact, and Individual Interest, a predisposition, developing over time, to re-engage with particular content. These definitions are useful for distinguishing between the types of interest experienced by students and as such were the basis for assessing how interested students in this study are in science lessons (Situational Interest) and in learning science in a more general sense (Individual Interest). In addition, these definitions provided a starting point with which to compare students' understandings of interest, as discussed below.

Levels of Situational and Individual Interest

Student Questionnaire 1: Section 3 (see Appendix 1) was developed in order to assess both students Situational Interest and Individual Interest levels as no pre-existing questionnaire tool could be identified (see Section 3.3). In total this section of the questionnaire contained 13 statements each for Situational Interest and Individual Interest. Thus, it was possible, by summing individual responses for each of the types of interest, to generate two interest scores for each student that fell between -26 and +26, a range of 53 points.

There was a large range for each of the scores: Situational Interest -23 to +26 and Individual Interest -26 to +26. The maximum score of +26 indicates a strong level of interest and conversely a score of -26 would indicate a disinterest in science. However, as Figure 4.1 shows, the scores show a distribution close to normal with around 50% of the students scoring between -2 and +10 for both Situational and Individual Interest. Furthermore, more students reported a positive score (Situational Interest = 66%, Individual Interest = 58%) than a negative score (Situational Interest = 34%, Individual Interest

= 36%) and only a small percentage of students recorded a score of 0, thus showing neither interest nor disinterest (Situational Interest = 4%, Individual Interest = 6%).

The mean and standard deviation (see Table 4.1) are similar for both Situational Interest and Individual Interest scores, i.e. the mean Situational Interest Score is 3.22 (Standard deviation = 9.70) and the mean Individual Interest Score is 2.88 (Standard deviation = 9.23). Further analysis demonstrated that there is no significant difference between the mean Situational Interest score and the mean Individual Interest score as the standard error levels are ±0.446 and ±0.424 respectively. It is notable, however, that more students scored close to the extremes of the scale for Situational Interest than for Individual Interest; 2.5% more students scored between -26 and -15 for Situational Interest than Individual Interest and, similarly, 2.8% more students scored between +15 and +26 for Situational Interest.

Table 4.1 Summary of Student Interest Scores.

	Mean (SD)	Maximum	Minimum
Situational Interest	3.22 (±9.70)	26	-23
Individual Interest	2.88 (±9.23)	26	-26

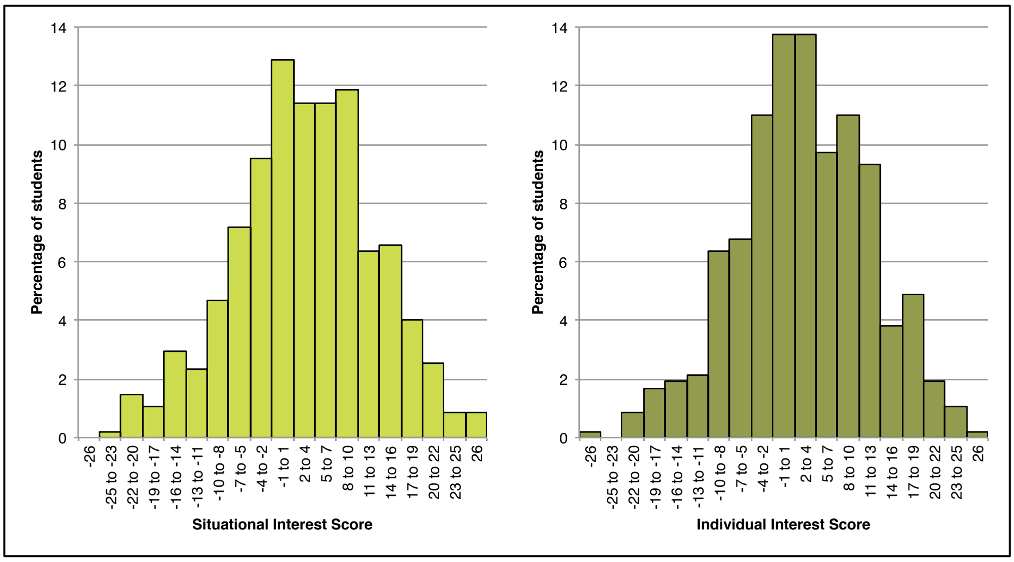


Figure 4.1 The distribution of Situational and Individual Interest Scores for the student participants. Data collected from Student Questionnaire 1: Section 3.

To investigate these similarities further a Pearson's r correlation was carried out between individual students' scores for both types of interest (see Figure 4.2). The results of this show a strong correlation ($r = 0.856$, $p<0.005$). Furthermore, there is a relatively even split between students who scored more highly for Situational than for Individual Interest (50%) and students who scored more highly for Individual than Situational Interest (41%), with the remaining 9% of students reporting the same levels for both types of interest. The possible reasons for this will be examined in Section 4.5.

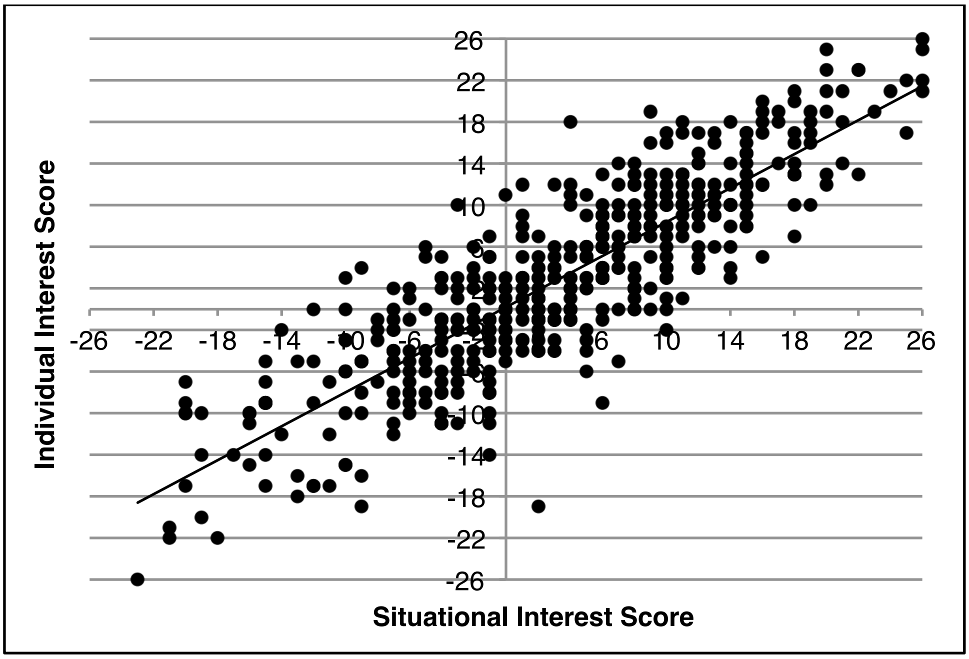


Figure 4.2 Individual students' scores for Situational Interest when plotted against their score for Individual Interest.

Student views of the nature of interest

The students had some clear views as to the nature of interest, how it develops and the importance it has for their willingness to fully engage in learning, as demonstrated by the quotations below:

> S1: Some things as soon as you see them they just grab ya, other things are kind of like oh yeah this is quite good but then sometimes you just sit down and are like why did I even decide to pick this subject and then once you have got that in

> your mind you can't get it out so I just feel like I am going to lessons that I don't even want to be in so I'm not putting any effort in. (Student Focus Group, 1 May 2014)

> S2: Like because we don't enjoy it we don't want to be there then rather than being like then I don't, like, enjoy it then maybe, like, I should try and then we'll understand it and then start to enjoy it, we're like what's the point we don't want to do it we're not here so we don't try we don't do any work it's kind of like we shut our brains off. We're only learning what we need to know for the exams then we don't care. (1 May 2014, Student Focus Group Interview)

The students were also aware that their interest may be shaped externally by factors such as the current zeitgeist, for example, the current concerns of 'society' as a whole. The following quotations are taken from a discussion comparing interest in biology and interest in geography as subjects.

> S1: At the moment in life we're [society] more focused about the environment around us and what we do to change it or make more sustainable.

> S2: Yeah, I think the majority of people are more focused in how to sustain the planet than- [finding cures for diseases]. (1 May 2014, Student Focus Group Interview)

When these quotations are taken in the context of the larger discussion it was clear that the students believed, that although we need doctors and medical researchers, the feeling in society was that it is more important for the general population to focus on sustainability.

Key findings

The key findings, summarised here, will be discussed in Section 4.5. The levels of interest reported by students cover the whole range measured, from a very high level of interest to no interest at all; the scores are approximately normally distributed with mean scores of 3.22 and 2.88 for Situational Interest and Individual Interest respectively. There is greater interest in science and science lessons than disinterest, and there is greater spread of scores for Situational Interest than Individual Interest.

The measurement tool used in this research revealed no significant difference between students' levels of Situational Interest and Individual Interest and actually demonstrated a strong correlation between them.

Student responses to both the questionnaire and focus group interviews show that they are aware that interest can influence their learning in a number of ways and that interest itself can be triggered or supported by different experiences.

4.2 Generation of Interest Factors

The Student Questionnaire 1: Section 1 (see Appendix 1) was used to collect data regarding students' beliefs about what makes science lessons interesting. Students were asked to select the extent to which they agreed with a number of statements using a Likert scale with regards the following question:

> How interesting do **you** find each of the following activities or opportunities? Please place a tick in only one of the boxes on each row to indicate how interesting you do, or think you would, find each of the following.

The rank order of students' strength of agreement with the statements, based on mean scores, can be found in Table 4.2.

Table 4.2 Rank order of the statements regarding things which will increase student interest in science according to student responses (Statements were from Student Questionnaire 1: Section 1 and scored as follows: -2 = strongly disagree; -1 = disagree; 0= neutral; +1 = agree; +2 = strongly agree).

Rank	Item	Mean Score	Standard Deviation
1	When I can choose who to work with	1.31	1.00
2	Carrying out practical work	1.20	1.01
3	Doing well in tests or assignments	1.05	1.09
4	Working in small groups	0.96	1.12
5	If I have a sense of achievement	0.95	1.07
6	Doing things which are related to my future career	0.94	1.06
7	If I learn strange facts	0.92	1.10
=8	Doing something instead of the teacher just talking	0.91	1.08
=8	Watching videos	0.91	1.17
10	When the teacher is knowledgeable	0.80	1.05
11	Feeling I know what I should be doing	0.78	1.05
12	Being able to pick the topic I will study	0.77	1.05
13	Learning information which is relevant to me	0.71	1.02
14	Using computers in our class	0.70	1.11
15	If I can see the science we're learning is important in life	0.69	1.01
16	Having the opportunity to explore the unknown	0.68	1.08
17	If I feel I have control over my work	0.67	1.00
18	If it helps me understand how the world works	0.63	1.05
19	Being able to present the information in a way I choose	0.60	1.66
20	If the teacher is interested in the lesson	0.58	1.20
=21	If I am supported in making good choices	0.56	0.94
=21	Doing tasks which will help me prepare for examinations	0.56	1.13
23	Learning the information in different ways	0.54	1.09
24	If I know something about the area of science we are studying	0.48	1.02
25	Making models to help explain scientific ideas	0.46	1.15
26	Using models to explain difficult theories	0.44	1.12
27	Being given responsibility for my work and learning	0.43	0.98
28	Watching the teacher demonstrate an experiment	0.40	1.20
=29	Having the opportunity to solve problems	0.39	1.05
=29	Having the opportunity to carry out independent studies	0.39	1.06
31	Doing drawings which show scientific ideas	0.36	1.18
32	Doing mind teasers	0.35	1.29
=33	If I am given challenge	0.34	1.04
=33	If there is feedback on the choices I have made	0.34	1.06

=35	If I have to think about the ideas	0.33	1.02
=35	Doing logic puzzles	0.33	1.26
37	If I can see the links between new information and something I have previously learnt	0.24	1.00
38	If I already know something about the lesson topic	0.23	1.16
39	Developing a better understanding of scientific concepts	0.21	1.05
40	If I can see the link between the activities and the learning objectives	0.13	1.04
41	Doing drama to model scientific ideas	0.07	1.37
42	Being able to discuss the topic with my teacher	0.05	1.09
43	If I can see the link between the resources and the learning objectives	0.04	0.98
44	Being able to discuss the topic with the rest of the class	0.03	1.00
45	Developing an understanding of the links between topics	-0.02	1.06

Based on the Likert scale (-2 to +2) where 0 is neutral, it is possible to argue that mean scores of +0.5 and above all indicate agreement with the statement. Mean scores of -0.5 and below show disagreement and scores between -0.49 and +0.49 are neutral. Thus it is clear from Table 4.2 that overall students agreed the factors described by the top 23 statements can increase interest levels but were ambivalent about the effect of the points made in the remaining 22 statements.

Furthermore, it can be seen from the means and standard deviations of the scores for each statement that the majority of students either agreed with, or were ambivalent, about the first three statements: when I can choose who to work with; carrying out practical work and doing well in tests or assignments. It is important to note that no students felt that these things reduced their interest in learning science. On the other hand the data for the statements which were ranked as having the lowest importance indicate that the proportion of students who have agreed that these things increase interest is the same as that of students who have disagreed with this statement on increasing interest. The vast majority of the statements show similar levels of variation, as indicated by the standard deviation scores (Standard deviation = 0.98 to 1.26). However, two statements show larger variation than the others; ‘Being able to present information in the way I choose’ (Standard deviation = 1.66) and ‘Doing drama to model scientific ideas’ (Standard deviation = 1.37). One explanation for this is that students may have had limited, or varying, levels of experience of these two items and therefore based their responses on either a small number of experiences or their feelings about what impact these may have on their interest level.

Understanding the component factors

Based on the pilot study in testing the questionnaire, in order to understand how these items cluster, a factor analysis, with varimax rotation and Kaiser Normalization, was conducted. As is conventional, Eigenvalues equal to or greater than 1.00 were extracted. With regard to the 45 items used, orthogonal rotation of the items yielded six factors, accounting for 16.4%, 9.5%, 6.9%, 6.8%, 6.5% and 6.0% of the total variance respectively, a total of 52.3% of the total variance explained. The factor loadings are presented in Appendix 7. To enhance the interpretability of the factors only variables with factor loadings as follows were selected for inclusion in their respective factors: > 0.623 (factor 1), > 0.615 (factor 2), > 0.638 (factor 3), > 0.516 (factor 4), > 0.566 (factor 5) and > 0.612 (factor 6). The factors have been given names that best describe the elements each factor encompasses. These names are, respectively: *Personal endeavour; Exploring science; Puzzles; Control; Learning from others; Modelling*. The component items are presented in Figure 4.3.

Factor 1: Personal endeavour	Factor 2: Exploring science
If I feel I have control over my work Learning the information in different ways If I know something about the area of science we are studying If there is feedback on the choices I have made Learning information which is relevant to me If I have a sense of achievement	Being able to discuss the topic with my teacher Developing an understanding of the links between topics Developing a better understanding of scientific concepts
Factor 3: Puzzles	**Factor 4: Control**
Doing logic puzzles Doing mind teasers Having the opportunity to solve problems	Being able to pick the topic I will study Being able to present the information in a way I choose Feeling I know what I should be doing
Factor 5: Learning from others	**Factor 6: Modelling**
Watching videos When I can choose who to work with Working in small groups	Doing drama to model scientific ideas Making models to help explain scientific ideas Using models to explain difficult theories

Figure 4.3 Component items of factors for increasing interest in learning science.

To further understand the role that students believe these factors play in supporting the development of student interest the mean strength of agreement with each of the Interest Factors was compared (see Figure 4.4). This, and all subsequent analyses, are presented as figures, with mean scores and 95% confidence limit bars, as these illustrate the trends clearly. The data table for Figure 4.4 can be found in Appendix 7. The mean scores show that overall students agree that *Learning from others, Control* and *Personal endeavour* increase their interest in learning science, with 95% confidence limits showing that the mean scores are significantly different for the majority of these factors. However, students are ambivalent with regards the effect that *Modelling, Puzzles* and *Exploring science* has on interest levels. It is worth noting that the mean score for *Exploring science* is significantly lower than the mean scores for all other factors. Each of the factors will now be considered in turn.

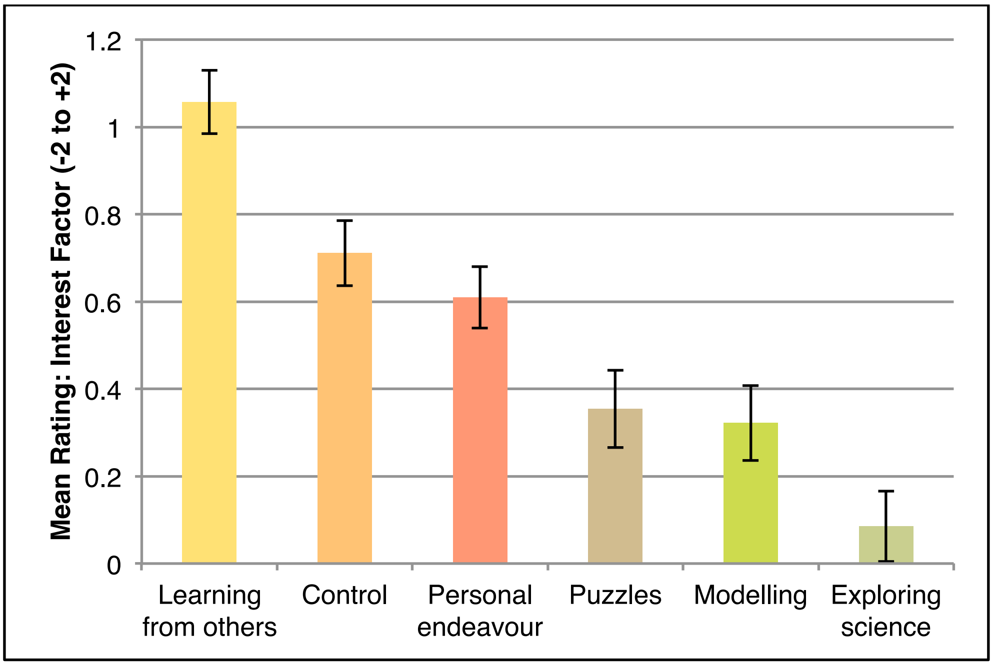


Figure 4.4 Mean strength of agreement with the Interest Factors (1.00 = agree, 0.00 = neutral, -1.00 = disagree).

Learning from others

The factor that students most strongly agreed with was *Learning from others.* This finding is not surprising, as many teachers would anecdotally state that students often ask if they can move seats or if they are going to be watching a video during a particular lesson. Although students were clear during the focus group interview (7 Feb 2013) that they felt that working with others made them more interested in lessons, they also had clear views with regards to the importance of which individuals they worked with:

> S1: I think it's better when they're your friends because you're more likely to like talk to them about it=S2: yeah==S3: yeah== but when it's people you don't know you're just sort of like sitting on your own. (7 Feb 2013, Student Focus Group Interview)

However, the person they are working with does not always have to be a friend: "I wouldn't choose to sit next to [student] and [student] but we work quite well as a group because we've always worked in that group". Furthermore, factors other than friendship can have an impact on how comfortable students feel about working with their peers. The following quotation is from two students who clearly felt intimidated when working next to some of their friends whom they perceived to be gaining higher grades and finding the work easier than themselves:

> S1: It's weird like, <sometimes I feel put off when I'm sat next to . . . student X> and student Y too because student Y is dead, like- [S2: Yeah] S1: it's not like we are not clever, we get things but=
> S2: we don't get A*s all the time=
> S1: yeah like we do try=
> S2: we're just average aren't we?
> (1 May 2014, Student Focus Group Interview)

Also included in this factor is the item 'watching videos'; however, from discussions with the students it is clear that they feel that the videos must be relevant to their learning and should not be over used or replace other learning methods.

> S1: We just watched videos, we watch videos every lesson in physics
> S2: They're not even relevant to what we're doing () *This was said in a very negative manner implying that videos every lesson do not interest the students.*
> S1: ((laughing)) He's just like 'watch the video'
> HD: Sorry, what were you saying?
> S3: I like it when you like actually do stuff cos then you're like not day dreaming like=S1: yeah.==S2: yeah.==like when your like being told stuff all the time and you don't take it in cos as you're just not listening cos it's boring when you're like=
> S1: =doing practical=
> S3: =yeah doing practical.
> (7 Feb 2013, Student Focus Group Interview)

Control

Although many of these factors interact in a classroom setting it is clear to see the importance students place on 'control', both in terms of understanding what they should be doing and choosing how they want to present information, as demonstrated by students listening carefully to instructions:

> They sat in silence and listened and as soon as the teacher said "off you go" they started writing and discussing the task in small groups. (13 Dec 2012, Lesson Observation, Class 2)

The willingness of students to listen to instructions suggests that they are interested in the lesson and that they believe it is important for them to understand what is required of them for the task(s) which are being outlined. The focus of the discussions, which they entered into when starting the task, appeared to be two-fold: confirming the instructions they had been given and exploring the required science knowledge, indicating that the students were taking control of the task and their work.

It is clear from the students' responses that it is important for them to feel they have control over procedural aspects of the lesson as well as factors related to the information being learned:

> S1: I guess it's just like (.h) cos we KNOW what we're doing cos we KNOW when we are working on a practical we split in a certain way everyone splits in the same way you KNOW where you're sitting you KNOW how long you've got to do it because she explains everything so it's just like everything's structured and I like that. I don't like it when we don't know what we're doing. (7 Feb 2013, Student Focus Group Interview)

> S2: If like the lessons are not really structured or anything like that you're not, you don't really like you don't learn anything and then if you don't know what it is that you're supposed to

be to doing it's and you get a bit like if they don't explain it very well so you get like lost quite a lot it's kind of difficult to enjoy it and have an interest in it if you're constantly bothered like that you don't know what you're doing. (7 Feb 2013, Student Focus Group Interview)

Miss M is circulating the room questioning and guiding students and asks '[Student X] which are the protons?' Student X responds in an exasperated tone 'I don't care'. Calmly, Miss M says, 'I'll tell you then' and then goes on to explain how we tell how many protons an element has. Student X then completes the table. *She (the student) does this willingly with no more comments. It seemed as though the original resistance and not caring was, at least in part, as a result of not knowing what to do or what was expected. Once it was explained the task was completed easily.* (2 Jul 2013, Lesson Observation Class 4)

Personal endeavour

Allowing students space to shape a task and to choose which aspect of a topic they would like to explore is one way of increasing student interest through *Personal endeavour*:

One concern was that the students may be 'switched off' to this topic as they have covered the dangers of smoking in PSE and science lessons at least three times since joining secondary school. However, they worked hard and were engaged in the tasks. It may also have been that they were allowed the opportunity to explore the topic for themselves and therefore could research aspects they chose to, thus allowing them to 'fill gaps' in their own knowledge. (15 Feb 2013, Self reflection, Class 2)

Students were given the opportunity to 'discover' the practical for themselves as they were given an instruction sheet and,

> unlike many lessons, the teacher did not demonstrate or talk through the method in detail before the students started it. This appeared to increase the interest of around half of the class who worked in groups to follow the method. Some groups did not appear interested in following the instructions for themselves, but asked their friends what they were meant to be doing. However, when the colour change started that did grab their attention for a while, but I am unsure they were interested in why the colour change happened. (13 Dec 2012, Lesson Observation, Class 2)

One aspect of *Personal endeavour* is the student feeling they know something about the area they are studying. One student commented on this as follows: "I understand it and I feel that if I can understand it that much now then as I get older I'm just going to be able to understand it more. If you start and you're like 'I don't get it' then it's not going to get easier it's just going to get harder" (7 Feb 2013, Student Focus Group Interview). Furthermore, the importance of prior knowledge was highlighted when the students discussed the different subjects and topics that they found interesting, with the most important factor, in their view, being to have some basic understanding of that area of knowledge:

> S1: I don't think that it is the way that it is taught that makes it interesting, I think it's like if you have a basic understanding at the beginning. Like when we learn something new completely I'm like I just don't understand anything at all and then if you like have a basic understanding and then if like a lesson after that you go into more detail. (1 May 2014, Student Focus Group Interview)

Receiving feedback on the choices they have made is one of the component statements of *Personal endeavour.* Feedback also allows students to be aware of the extent to which they have developed their knowledge of a topic, as expressed by Student 1: "I like to be corrected because that means when we do the test we /know\ what's wrong and what's right" (7 Feb 2013, Student Focus Group Interview). The importance of feedback to students appears to have, as well as a cognitive component, a strong affective component as students were clear that they felt disappointed if teachers did not spend time marking books and reading the work completed.

> S1: If you spend a lot of time on something, and they [the teachers] can't be bothered to read it or look at it then it's like why did I bother putting so much effort in [S2: Yeah] if you're not even going to acknowledge it.
> S3: It's like when teachers mark your book and if you get a high mark you like you want to show your parents but the thing is if you just find that you've got a load of little red ticks all the way through and obviously she hasn't read any of it, she's just gone through pages and just, ticked bits and not corrected spellings where I obviously know, cos I'm terrible at spelling, that they are wrong.
> S2: But a lot of teachers just like glance over it and go like yeah that's about right, it looks about right and it's like well can you do it specifically. (7 Feb 2013, Student Focus Group Interview)

Another reason for the importance of feedback is to allow students to gain a sense of achievement as they progress with their studies. It would be expected that students make progress throughout their studies but sometimes it can come as a surprise to them:

> When asked what was 28 days, Student X shouted out "Menstrual cycle". I responded "Correct, it is usually about 28 days, the same as the moon cycle". Student X seemed genuinely shocked that he was correct and even said

> "[laughing] I was just being immature, who'd have thought I was right?". After this point, early on in the lesson, Student X was more involved in the discussions and spoke to me about the topics more than he has done in recent lessons. (27 Jan 2014, Self-observation, Class 1)

The majority of the students interviewed expressed the view that they were more interested in the science subject that linked to their future career aspirations, for example, one student wanted to do something in the field of neuropsychology and thinks that "that makes me more interested in biology and stuff like that" (7 Feb 2013, Student Focus Group Interview). Those who did not express this view were considering careers that are not strongly linked to any of the sciences.

<u>Puzzles</u>

Puzzles were not rated highly by the students as increasing their interest in learning science and they expressed this view a number of times.

> S1: so when you did the [biological] rhythms you just put all the numbers of the page and like went try and do it whereas we didn't know what any of the rhythms were or anything like that, which is why not many people did anything. (1 May 2014, Student Focus Group Interview)

However, my recollection was that the majority of students started trying to guess what the numbers meant. Some groups tried to come up with 'comedy' answers which showed they were clearly thinking about the task whereas other students reached for their revision guides and started looking though in an attempt to find the right answer. Further lesson observation evidence also suggests that the solving of puzzles does stimulate students to be involved in lessons.

> Mr T put three numbers on the board and asked students to work out what they represent. The room erupted in chatter

and discussions with each table trying to come up with answers. (7 Dec 2012, Lesson Observation, Class 1)

Miss M starts the periodic table bingo game by asking questions e.g. “My atomic number is 7”. After thinking time she invites students to give the correct answer. Students are enthusiastic and focused on the tasks. They are helping each other when they struggle. Miss M directs some questions to individual students and when they cannot answer she explains the theory to them e.g. the 3rd period is the 3rd row down. *It is interesting that although this activity was introduced as a competition between the individual students and that the winners will get merits to be added next year very quickly the students start collaborating and helping each other – neither instigated nor discouraged by the teacher. This emphasises the support and positive relationships which are present within this group of students.* (4 Jul 2013, Lesson Observation, Class 2)

<u>Modelling</u>

Activities which required students to create physical models or explicitly use cognitive models occurred less frequently than opportunities for introducing other Interest Factors such as *Learning from others.* However, when physical models were used in lessons students responded in a positive manner as the exchange below demonstrates:

I was wandering around the classroom collecting in the jelly baby DNA models to put them together in one big class model. All groups were working on the origami models and chatting quietly. As I reached the far table Student 1, with a big grin on her face, said “Miss, if I could rate this lesson I would give it 10 out of 10”, Student 2, smiling, added “I’d give it 10 out of 10 if we could eat [the jelly babies]”. I asked Student 1 why this was the case and she responded “because it is fun and interesting and a good practical which kids would like and you learn something as you do it”. I thanked her for her feedback and said that I was glad she enjoyed the lesson before moving on to continue collecting equipment and talk with some other students.

This exchange was incredibly rewarding for me as it was entirely spontaneous on the part of the student. It provided further evidence for a number of factors for increasing student interest, namely that they enjoy model making, problem solving and working in groups. There was a good level of challenge as the students were presented with an instruction sheet and the equipment and asked to build the model with no further guidance. Secondly it surprised me as to the level of openness and willingness to give feedback on the part of the students involved. I am inferring from this that they feel we have a good working relationship and that I am open to feedback from them. Student 1 in particular must be confident that I will welcome the discussion otherwise she would not have commented so openly. I guess the real test of this will be if they feel able to feed back when they feel a lesson or activity is not going as well as they would like.

The jelly baby modelling activity had a good level of challenge as the students had to work together to follow the instructions and build the model. I did not offer them help with this until they had attempted it. This gently forces all students to engage in the task. This involvement appeared to lead to an increase in interest. (19 Jun 2013, Self-observation, Class 2)

Cognitive models, which are common in science, were used more frequently than physical models; however, the fact that they are models was not generally made explicit to students and as such appeared to be treated in the same way as other knowledge which must be learned:

> Miss M explains "what you need to know at GCSE" is that electrons move around the nucleus in discrete shells, like the solar system, the planets to not cross each other. She then draws a GSCE level diagram and explains how you 'fill' the shells. *I am unsure if the students are aware that this is a representation or model of atomic structure, rather than what atoms actually look like. This has been implied through the explanation (what is needed and link to the solar system) but the teacher has not been explicit about the idea of models.* (4 Jul 2013, Lesson Observation, Class 2)

> *The students are studying the 'solar system' model of atomic structure and electron arrangement. I am unsure if the students were aware that this was a conceptual model and representation rather than the actual arrangement as this distinction was not referred to explicitly during the lesson*. (2 Jul 2013, Lesson Observation, Class 4)

Despite having the impression that the students do not always recognise when a model is being used, the students do appear to be aware that having cognitive models or pictures can support their understanding. Furthermore, they seem to consider this way of thinking to be different from that of procedures or processes they have to go through to, for example, achieve a sporting goal or solve a mathematics problem. This is clearly illustrated by the students in the quotation below:

> S1: So if you started out running and you want to get to get to run a mile . . . you start out running two-hundred metres, then four-hundred then eventually you get to run a mile. It's quite straight forward. >Whereas, like, if you want to understand part of biology< it might be like harder and more steps. You

> actually like have to be able to picture it to understand what's going on.
> S2: Yeah, there's like more knowledge behind like scientific . . . things, than like sporting cos you can either do it or you can't in like sports whereas you have to know quite a lot to get to one point. (1 May 2014, Student Focus Group Interview)

<u>Exploring science</u>

On average, there was only a low level of agreement that *Exploring science* is a factor that increases students' interest in learning science. As suggested below, one reason for this may be related to the specific topic being explored.

> S1: the chemistry lesson we did the other day on like the atomic structure of atoms was good.
> S2: [Yeah, that was-]
> S1: [I really like that one]
> HD: Why?
> S1: I don't know it was just interesting.
> HD: W:hy? The topic was interesting or what you were doing made it interesting?
> S1: No the topic was interesting. We weren't really doing anything we were just like talking about it.
> S2: In chemistry we can kind of like if you have a question then ask it and then you kind of go on a side track about that as well but she still keeps it to the same topic so it's like controlled but we can talk about it. (7 Feb 2013, Student Focus Group Interview)

In this quotation the students also allude to the importance of control of and structure to the lessons.

How interesting students find *Exploring science* and developing an understanding of a scientific subject may be related to the perceived level of challenge and a student's self-efficacy regarding the subject area:

> S1: I got more interested in it when it got towards like, it was just before the carbon cycle and plant hormones and stuff like that because I can do that, I can do the plant hormones, erm, and B2, that's okay but some of it's really hard. (1 May 2014, Student Focus Group Interview)

Two factors which influence the strength of this factor are the topic students are exploring and the specific approach to a topic. The quotations above regarding *Personal endeavour* and relevance suggest that if they see the topic as being relevant to their future careers or other aspects of their lives, or if they have some existing knowledge, then students are interested and willing to 'explore' the science behind these topics through discussion with their peers and teachers. Although the questionnaire responses resulted in this being the least strongly agreed with factor, the behaviour of students in lessons did not entirely reflect this. In every lesson observed at least one student asked a question which was relevant to the learning objectives but added depth or breadth to their understanding. Some of the lessons observed had a large period of time devoted to answering student questions about the topic; for example, 15 minutes of the lesson Mr T taught on the effects of alcohol (7 Dec 2012) was spent with the students asking questions which were either directly related to the topic, "you know in films when they put alcohol to their eye ball, is that to get it into your blood quicker?", or which followed on from previous questions and responses, "if someone hits you in the kidney do you die?". Similarly, all students completed the majority of tasks set for them to do each lesson, although this does not necessarily mean they were interested in the work.

Throughout the data there are a number of statements from students relating to how the scientific topic being studied influences how interested they are in the lesson: “I don’t like Physics”; “I like biology”; “I like the skeleton” (7 Feb 2013, Student Focus Group Interview). Although, for reasons discussed in Section 2.7, the data collection did not focus on issues relating to interest in specific topics, subjects or domains.

Inter-relatedness of Interest Factors

There is overlap between the Interest Factors generated by the questionnaire responses; for example, the statement ‘If I feel I have control over my work’ was placed by the factor analysis as a component of *Personal endeavour* rather than *Control*. This overlap was also observed in students’ responses during focus groups as demonstrated by the following exchange:

> S1: In our chemistry=HD:right=we did like the same thing twice but it was really good the second time but the first time it was really rubbish.
> HD: Why was it (. .) good the second time but rubbish the first time?
> S1: Well cos like we watched this video but we’d already seen it and the first time we didn’t know why we were watching it but the second time we did (.h) and it was all about like how the periodic table of elements was like formed and everything and that was dead good cos it was like everything was explained and Miss like understood what she was talking about so she could like tell us loads of stuff about it.
> S2: And it was in more detail [and-]. (7 Feb 2013, Student Focus Group Interview)

This quotation could suggest that *Control* is important to this student as the second time she watched the video she understood what she should be doing, but also her interest could have increased as a result of having already gained some knowledge about this area from the first viewing which is important in *Personal endeavour.* In addition, the student also alludes to the importance of *Exploring science* on increasing her interest.

Similarly, during a lesson on the effects of smoking a number of the interest factors could be identified as being present. All students were fully engaged in the task and showed signs of interest: they were smiling and asking curiosity questions.

> The work produced was creative but still included scientific knowledge and evidence for this knowledge – which is what they were asked to do. Students spent a large amount of time discussing the science, the issues and how they would present their information as well as seeking further research (getting the leaflets). (15 Feb 2013, Self-observation, Class 2)

The design of the task in this example allowed the students high levels of *Personal endeavour* (they all knew something about the dangers of smoking and they could research the information in a number ways), *Control* (they chose what component of tobacco to research and how to present this information) and *Learning from others* (students were asked to work in groups).

Given that the nature of these factors and the qualitative data collected, it is not surprising that there are significant correlations ($p<0.0005$) between the students' responses to each of the factors as shown in Table 4.3. The strength of these correlations highlights the complexity of interest and the challenge faced when trying to isolate specific factors. Alternatively, these relationships could highlight underlying factors which were not identified by the questionnaire items; this will be discussed further in Section 4.5.

Table 4.3 Calculated values and Significance levels for Pearson's r tests between each of the Interest Factors. All results are significant at $p<0.0005$.

	Personal endeavour	Exploring science	Puzzles	Control	Learning from others
Exploring science	0.548				
Puzzles	0.307	0.402			
Control	0.576	0.414	0.281		
Learning from others	0.368	0.188	0.215	0.324	
Modelling	0.447	0.325	0.330	0.289	0.337

Interest and practical work in science lessons

The majority of the items ranked in the top half of statements for increasing interest in learning science (see Table 4.2) are encompassed by the Interest Factors discussed above. However, a number of the high-ranking statements did not cluster with other statements; most likely due to them being unique with regards the aspect they asked about. One of these statements 'Carrying out practical work' is key within the context of this investigation and it is a key component of science lessons.

Although practical work did not feature in any of the Interest Factors generated it was the second most strongly agreed with statement from the questionnaire and it was clear from the focus group interviews and lesson observations that students enjoyed 'practical work', although this term was used to refer to a number of activities. One marked finding is the enthusiasm with which students want to engage with the practical tasks:

> Miss M starts the practical task by asking "what is the first thing you need to remember?" the whole class answered "safety glasses/goggles". She then said "off you go" and all students, apart from one, got up quickly and started collecting equipment. *This is a much quicker reaction than the one*

> *shown when these students are asked to start work on a paper based activity.* (13 Dec 2012, Lesson Observation, Class 2)
>
> When Miss M takes the Calcium over to the group of 4 she asks "who is going to put this in?" All of the students shout saying they want to. *The practical work aspect covered Exploring science and the focus on working to do this as a group allowed Learning from others. This part of the lesson seemed to interest students the most as they were eager to see what would happen when they added the elements.* (2 Jul 2013, Lesson Observation, Class 4)

A number of different reasons for this enthusiasm and interest were observed although often it was clear that what started to trigger the Situational Interest did not in fact lead to Situational Interest developing:

> As the reaction finished Student 1 "this is an amazing blue; I wish my eyes were this colour." As a result of this comment Student 1 and Student 2 then started talking about various things; contact lenses, secret Santa. *This was a really nice moment in the lesson as, although they very quickly moved off topic, for a moment Student 1 was fully absorbed in the result of the reaction.* (13 Dec 2012, Lesson observation, Class 2)

However, at other times the practical task led to Individual Interest where students made extra efforts to reengage with the work. One example of this was the cloning plants practical which was carried out with Class 2. This is a relatively short activity where students take a leaf cutting from a geranium plant, dip the stem in rooting powder, then plant the leaf in a cup of compost. The students appeared to become very attached to their cuttings and the first thing they did for the following four lessons after setting up this activity was to go to the windowsill to check on them. The concepts covered in these lessons linked to cloning, for example, different types of stem cells, and the students seemed more interested in these lessons than in others and than students who have done this activity in previous years. A number of students also came back during their lunch-breaks to water the cuttings and one student in particular frequently visited the laboratory and asked about his plant:

> During the lesson I was walking around collecting in some equipment and as I approached Student 1's bench he asked, "Miss, will Mo [the name he has given to his plant] one day be a real big plant?". I reassured him that, yes, if he keeps looking after it there is a good chance it will survive. I took this opportunity to ask Student 1 what it was about the plant that had made him so dedicated to looking after it. He fumbled around for an answer and struggled to put together a clear reason but three main ideas emerged, firstly, that it was something they had made, secondly, that if they didn't look after it now it would mean the time spent 'cloning' it would have been wasted and finally that "you've got to care, haven't you?". (4 Oct 2013, Self reflection, Class 2)

Key findings

The questionnaire responses can be categorised into six Interest Factors: *Learning from others; Personal endeavour; Control; Puzzles; Modelling; and Exploring science*. However, students, on average, only agreed that the first three of these would increase their interest in learning science and were ambivalent about the final three. The relative importance of these factors was, for the most part, reflected in the level of interest which could be inferred from student behaviours in lessons. However, students reported, through Student Questionnaire 1 and Focus group interviews, that *Puzzles* did not increase their interest level, even though their behaviours in lessons suggested that activities which could be classed as puzzles triggered increased interest as demonstrated by behaviours such as positive emotional responses and increased frequency of curiosity questions.

Despite containing very different components, these factors are strongly related and the strengths of agreement of each factor with the other six factors all correlate at $p<0.0005$.

Unsurprisingly, ‘practical work’ is seen to be a key factor in increasing student interest in science lessons; however, this did not form a component of any of the Interest Factors generated. The role that practical work may play in increasing interest, along with the rest of the findings presented above, are discussed further in Section 4.6.

4.3 Generation of Purpose Factors

Student Questionnaire 1: Section 2 (Appendix 1) was used to collect data which assessed what students believed to be the reasons for studying science at Key Stage 4. Table 4.4 shows the rank order for the responses gained from the student questionnaire as well as the mean score and standard deviation for each of the statements. The most strongly agreed with purpose is ‘to prepare me to get a GCSE in science’. This may be a somewhat circular argument – I am studying GCSE science to get GCSE science – but it is also very informative in that it suggests that students place more importance on the end point of their two years study rather than the experiences throughout the two years. The majority of statements, on average, are mildly agreed with; however, the statements relating to future careers and interest in science show the greatest variance. It is possible that there is an issue with participants displaying demand characteristics when responding to this section, especially if they believe that any item included must be a reason for studying science at Key Stage 4. Therefore, the responses will be discussed in terms of the comparative, rather than absolute, importance students have placed on each item.

Table 4.4 Rank order of the purpose of learning science in school statements according to student responses (Statements were from Student Questionnaire 1: Section 2 and scored as follows: -2 = strongly disagree; -1 = disagree; 0= neutral; +1 = agree; +2 = strongly agree).

Rank	Item	Mean Score	Standard Deviation
1	To get a GCSE qualification	1.04	0.91
2	To prepare me to get a GCSE in science	1.03	0.90
3	To learn scientific facts	0.71	0.86
4	To help me to get a job or go on to further education	0.69	0.94
5	As the knowledge and skills are important in life	0.61	0.87
6	To teach me things which will be useful for a job	0.60	0.92
7	To teach me how to use different types of scientific equipment	0.59	0.86
8	To help me understand current environmental issues	0.57	0.88
=9	To develop ideas about how the world works	0.56	0.83
=9	To prepare me for my future career	0.56	0.97
11	To help me make decisions about scientific issues	0.50	0.87
=12	To teach me about how to be healthy	0.49	0.88
=12	To explain how scientific investigations are done	0.49	0.82
=14	To make me more interested in science	0.48	0.98
=14	To learn some scientific theories	0.48	0.85
16	To teach me how to interpret scientific data	0.45	0.85
17	To understand what science has achieved	0.43	0.87
=18	So people do not take for granted what has been achieved	0.29	0.92
=18	To learn how scientists investigate the world	0.29	0.90
=18	To give me confidence when making decisions	0.29	0.94
21	To interest me and make school enjoyable	0.22	1.03
22	We all learn science because the country needs scientists	0.09	1.03
23	To train people to be scientists	0.00	0.98
24	To learn about different scientists	-0.03	0.94
25	Because it is just so interesting	-0.07	1.09

The mean scores for the statements from Student Questionnaire: Section 2 show that students agree with 11 of the statements (i.e. score ≥0.5) but are ambivalent about the remaining 14 (i.e. scores fall between -0.49 and +0.49). The standard deviation values show that the variation in student responses is similar for each of the statements, ranging from 0.83 to 1.09.

Component factors

As with the Interest Factor data a factor analysis, with varimax rotation and Kaiser Normalization, was conducted in order to understand how these items cluster. As is conventional, Eigenvalues equal to or greater than 1.00 were extracted. With regard to the 25 items used, orthogonal rotation of the items yielded four factors, accounting for 19.4%, 15.8%, 11.7% and 11.1% of the total variance respectively, a total of 58.0% of the total variance explained. The factor loadings are presented in Appendix 8. To enhance the interpretability of the factors, only variables with factor loadings as follows were selected for inclusion in their respective factors: > 0.627 (factor 1), > 0.623 (factor 2), > 0.560 (factor 3) and > 0.556 (factor 4). Of the 25 original statements, 18 are included in these four factors. The factors have been given names that best describe the elements the factor encompasses. These names are, respectively: *Developing knowledge; Professional relevance; Personal relevance* and *Social relevance*. The component items are presented in Figure 4.5.

Factor 1: Developing knowledge	**Factor 2: Professional relevance**
To teach me how to use different types of scientific equipment	To teach me things which will be useful for a job
To explain how scientific investigations are done	To prepare me to get a GCSE in Science
To learn scientific facts	To prepare me for my future career
To learn some scientific theories	To get a GCSE qualification
To teach me how to interpret scientific data	To help me to get a job or go on to further education
Factor 3: Personal relevance	**Factor 4: Social relevance**
To give me confidence when making decisions	To understand what science has achieved
To interest me and make school enjoyable	We all learn science because the country needs scientists
To learn about different scientists	To train people to be scientists
Because it is just so interesting	So people do not take for granted what has been achieved

Figure 4.5 Component items of factors for the purpose of learning science.

The strength of agreement with these factors was compared for all of the data where 1.00 = agree, 0.00 = neutral, -1.00 = disagree (see Figure 4.6). This, and all subsequent analyses, are presented as figures, with mean scores and 95% confidence limit bars, as these illustrate the trends clearly. The data table for Figure 4.6 can be found in Appendix 8.

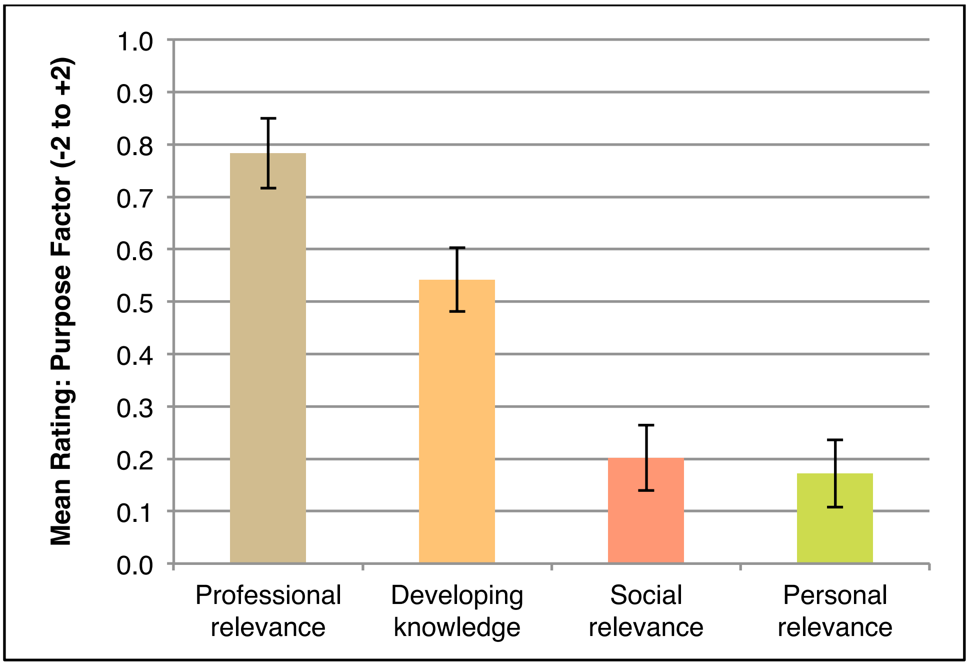


Figure 4.6 Mean strength of agreement with the Purpose Factors (1.00 = agree, 0.00 = neutral, -1.00 = disagree).

It is clear from Figure 4.6 that there are differences between how strongly students agree that each of the Factors identified is a reason for the studies they are about to undertake. Students, on average, agree that *Professional relevance* and *Developing knowledge* are purposes of learning science but are ambivalent about the importance of *Social relevance* and *Personal relevance* as the reasons for studying science between the ages of 14 and 16 years-old. Although there is no significant difference between *Social relevance* and *Personal relevance* these are both significantly lower than the next highest *Developing knowledge*, which is in turn significantly lower than *Professional relevance*.

Professional relevance

These findings are further supported by the data collected from interviews as the students referred to the *Professional relevance* of their studies more frequently that any of the other factors. This factor was referred to in a number of ways, the most frequent being illustrated by:

> S1: if I want to use chemistry and then I'll want to work hard now so I can do it later.
> S2: To have the option to do A' Level if you want to, if you get a good GCSE grade you can go to a good college or sixth-form and go onto good A' Levels. (7 Feb 2013, Student Focus Group Interview)

Similarly, although more implicitly, there was a focus on *Professional relevance* as the majority of assessment activities were based upon the examination criteria and content derived from the GCSE specification statements.

The students were also aware of the value of a GCSE in Science, even if they did not feel they wanted to enter a career with direct links to science, as demonstrated by:

> When you do like science you have like you have so many options you can like take, even when you have gone on to choose A' Levels. But if you like went on to do art and stuff you have to go on to do art. (7 Feb 2013, Student Focus Group Interview)

This was also the case even when they were discussing interest in lessons:

> HD: Is there any lesson you have been really interested in?
> S1: Science. I want to try to be a vet. I've already got me apprenticeship at Hartford vets = Researcher: fantastic = from sixteen. Erm, yeah, I just need to try and get me grades now. (2 Jul 2013, Student Focus Group Interview)

The influence, both positive and negative, that this factor can have on student interest and engagement in lessons was evidenced during lesson observations:

> Most groups are working in silence or quietly discussing it with each other. Student 1, Student 2, Student 3 and Student 4 are chatting about other things. *None of these students did very well in the recent mock examinations for science and since they got the results they have been less inclined to complete written tasks set in lessons.* Other students, who performed well in the mock examinations, are working diligently on the task. Student 5 completed very little work this lesson. *She also did not perform very well in her mock examinations both of which were surprising since she had been one of the most hard working students in the class last year and gained one of the highest marks in the class on the Science GCSE at the end of Year 10. I later found out that her family are planning to move back to Perth, Australia, having only been in the UK for a year and a half. This therefore means that she will not be completing her Additional Science, or any GCSEs, in the UK. It seems that since she has no Professional relevance for this work she is lacking interest and therefore not completing much work.* (12 Dec 2012, Lesson observation, Class 2)

<u>Developing knowledge</u>

All of the observed lessons and those reflected upon formally had *Developing knowledge* as a purpose, with the particular knowledge to be developed communicated explicitly to students by means of the learning objectives. In the majority of the lessons this reflected learning facts or theories, however, students were also required to develop an understanding of how investigations were carried out and how to interpret data and each time the students completed a practical task requiring scientific equipment they were developing their skills in using this equipment, although this was rarely stated as a learning objective.

Social relevance and Personal relevance

Both *Social relevance* and *Personal relevance* were often not included in the lessons observed, or were only covered in an implicit manner. If they were included it was often as tasks which did not form the core of the lesson:

> The focus of the homework task was personal relevance [questions regarding uses of DNA sequencing and related ethical issues] and this will be emphasised next lesson – the students are going to be the decision makers of the future and I would like them to consider implications of these decisions and what they need to know in order to make informed choices. (19 Jun 2013, Self-observation, Class 2)

Alternatively, the inclusion of these factors was as a result of the material included in the examination specification, for example, lessons on the effects of smoking and alcohol, and therefore could it could be argued that the purpose here is actually examination preparation through *Developing knowledge.*

Behaviour management as a purpose of science lessons

During both lesson observations and reflective discussions it was clear that teachers felt the purpose of their lessons was not solely related to the students learning science. Lessons also had a purpose regarding general behaviour and social interactions:

> [The purpose of the lesson was to] a) to remind them that they are a top set and that they should not have to be chased for work and b) to find out what they knew [about alcohol] and increase their biological knowledge rather than their socio-economic knowledge. (13 Dec 2012, Mr T Reflective discussion, Class 1)

Student X arrived wearing trainers rather than school shoes and teacher challenged her checking the reason for not having shoes. (13 Dec 2012, Lesson observation, Class 2)

You have asked for practical so listen please. You can't do it until I have explained it, they are the rules. (2 Jul 2013, Lesson observation, Class 4)

Unlike the Interest Factors the students' response to the Purpose Factors do not all show significant correlations (see Table 4.5). Although student scores for *Professional relevance, Developing knowledge* and *Social relevance* all positively correlate at the $p<0.0005$ level, there is no correlation between these scores and the students' scores for *Personal relevance*. This will be discussed further in Section 4.6.

Table 4.5 Calculated values and Significance levels for Pearson's r tests between each of the Purpose Factors. (* indicates significance at $p<0.0005$, ^ indicates not significant).

	Professional relevance	**Developing knowledge**	**Social relevance**
Developing knowledge	0.634*		
Social relevance	0.494*	0.572*	
Personal relevance	-0.026^	-0.004^	0.093^

Key findings

The questionnaire responses can be categorised into four Purpose Factors, which encompass the majority of statements from the questionnaire. Overall, students agreed that *Professional relevance* and *Developing knowledge* are key purposes of learning science at this level but were ambivalent about the importance of *Social relevance* and *Personal relevance*. Possible reasons for the differing levels of agreement with these factors are considered in Section 4.7 along with wider discussion about the Purpose Factors.

Professional relevance, Developing knowledge and *Social relevance* all correlate at $p<0.0005$; however, *Personal relevance* does not correlate with any of the other three factors. The relative levels of agreement with the Purpose Factors were reflected in the amount of emphasis that was put on these factors during the lessons observed and by both student and teacher comments during the focus group interviews.

Data from lesson observations and focus group interviews with teachers showed that teachers also feel they have a role teaching students about how to behave, although this was never raised by the students as being part of the purpose of their science lessons.

4.4 The relationships between Interest Levels, Interest Factors and Purpose Factors

Given the strong correlation between students' scores for Situational and Individual Interest (see Figure 4.2) it is not surprising that the students' scores for each of the Interest Factors show significant positive correlations ($p<0.0005$) with the students' scores for both Situational and Individual Interest since interest (see Table 4.6). This would suggest that re-engagement with specific content, can feed into supporting the development of a wider intrinsic interest. However, the interest level does not have the same relationship with the Purpose Factors. It is striking that only the students' strength of agreement with the Purpose Factor *Personal relevance* correlates significantly ($p<0.0005$) with their levels of interest, whereas none of the other Purpose Factor scores correlate with the scores for Situational Interest nor the scores for Individual Interest (see Table 4.6).

Table 4.6 Calculated values and Significance levels for Pearson's r tests between each of the Interest and Purpose Factor scores and the students' scores for both Situational Interest and Individual Interest. (* indicates significance at $p<0.0005$, ^ indicates not significant).

Interest Factors	**Situational Interest Score**	**Individual Interest Score**
Personal endeavour	0.418*	0.381*
Exploring science	0.530*	0.471*
Puzzles	0.309*	0.248*
Control	0.345*	0.274*
Learning from others	0.210*	0.126*
Modelling	0.284*	0.220*
Purpose Factors	**Situational Interest Score**	**Individual Interest Score**
Personal relevance	0.607*	0.580*
Professional relevance	-0.004^	0.044^
Developing knowledge	-0.012^	0.037^
Social relevance	0.056^	0.058^

When examining relationships between the Interest Factors and the Purpose Factors it was found that students' scores for *Personal relevance* correlated significantly with the student scores for each of the Interest Factors: *Exploring Science* 0.452, $p<0.0005$; *Personal endeavour* 0.383, $p<0.0005$; *Modelling* 0.279, $p<0.0005$; *Control* 0.267, $p<0.0005$; *Puzzles* 0.233, $p<0.0005$; *Learning from others* 0.195, $p<0.0005$. This is noteworthy as *Personal relevance* does not correlate with any of the other Purpose Factors nor do any of the other Purpose Factors correlate to any of the Interest Factors. These data, taken together with the level of agreement with *Personal relevance* reported, suggest that, despite claims to the contrary (Edexcel, 2013), students are, at best, ambivalent about 'increasing interest' being a purpose of learning science between 14 to 16 years of age.

4.5 Discussion: Interest levels and Interest Factors

The general levels of interest reported here; 61% and 58% of students had positive scores for Situational and Individual Interest respectively, are similar to those from previous research, for example, in the Student Review of the Science Curriculum (Planet Science, Institute of Education and Science Museum, 2003) 58% of the students, aged 16 to 19 years-old, agreed that GCSE science encouraged curiosity, one of the characteristics of Individual Interest. These findings are encouraging to the extent that they show the majority of students hold Situational and Individual Interest with regards learning science. Although, the mean scores for all students do not provide a detailed picture regarding how this interest is distributed between different groups of students which is an issue that is examined in Chapter 5.

The distribution of the scores is such that more students scored to extremes of the scale (-26 to -15 and +15 to +26) for Situational Interest than for Individual Interest. This may be explained by students being more confident in their feelings regarding science lessons; something they experience almost every day, than their general interest in learning science, as students can have very different experiences of, and opportunities for, engagement in science outside of the school classroom. A lack of confidence or awareness could result in students being more reticent in selecting ‘strongly agree’ or ‘strongly disagree’ as a questionnaire response, thus resulting in Individual Interest levels that are less widely spread across the population compared to Situational Interest levels.

A key finding from this research is the strength of the correlation between Situational Interest and Individual Interest, which can be interpreted in a number of ways. First, there may be no difference between the two types of interest, although all of the current theoretical models (for example, Hidi and Renninger, 2006; Silvia, 2001) suggest that there are at least two different phases; Situational Interest which is externally supported and Individual Interest which is more internally driven. Second, the questionnaire tool used may not allow these types of interest to be measured as independent factors. However, the questionnaire was carefully constructed using statements from pre-existing questionnaires which were then amended to ensure their relevance to asking about broad science interest and classified to link closely with expectations outlined in Hidi and Renninger's (2006) model of interest (see Section 3.3 for a full discussion of the questionnaire development). The most plausible explanation of the strength of this correlation is that the questionnaire does distinguish between the two types of interest and that this is a genuine relationship. The students may struggle to separate out the two types of interest as a result of their experiences of science being strongly grounded in school science, therefore the dominant content which externally supports interest development is that which is found in school science lessons. Alternatively, since Individual Interest is, to some extent, driven by a student's internal expectations of a task where a student has high Individual Interest it will increase the potential for them to experience Situational Interest. Similarly, if a student has yet to develop Individual Interest they have no internal trigger for Situational Interest and, as a result, they did not score highly for either types of interest as the questionnaire did not ask about specific content or lessons. The lack of specificity of the questionnaire could offer an explanation as to why, in contrast to the findings of this research, other studies have not found such a strong correlation between the two types of interest. For example, Chen and Darst (2002) measured student interest with regards learning motor skills and found no correlation between students' Situational Interest and their Individual Interest and suggest that this result supports the notion put forward by (Alexander, Jetton and Kulikowich, 1995) "that individual and Situational Interests are independent motivational entities and may have distinctive motivational functions at a particular learning stage" (Chen and Darst, 2002, p. 8).

In light of the points made above, these findings go little way to support, nor refute, the linear aspect of Hidi and Renninger's model, which proposes that Situational Interest must be present before Individual Interest can develop. If the score for Situational Interest was significantly higher than that for Individual Interest, then the data would fit with Hidi and Renninger's (2006) linear model; however, this is not the case for the students in this study where only 236 students, out of 475, scored more highly for Situational Interest than Individual Interest and 196 students had a higher score for Individual Interest, with the remainder having equal scores. The Model of Domain Learning (Alexander, 2004) could explain these differences as it proposes that Situational Interest decreases and Individual Interest increases as learning takes place; therefore, it could be hypothesised that those students who have an Individual Interest score higher than their Situational Interest score have more mastery of science.

Throughout Stage 2 of this research students were asked about their interest in learning science in a number of different ways. During one focus group interview students were asked directly what it meant to be interested in something and although students expressed some understanding many of them found it challenging to give a specific definition; perhaps because interest is such an abstract concept. As a result of this they often resorted to describing factors which could be classified as external motivators. This not surprising given the students' strength of agreement with the Purpose Factor *Professional Relevance*. Furthermore, at no point during this study did I witness a teacher (apart from myself) explicitly refer to something as 'interesting' in front of their students. It was not clear whether it is assumed by the school community that teachers find their subject area interesting, and therefore this does not need verbalising, or whether 'interest' is not valued in the same way as teachers' or students' academic achievement. It was clear, however, that 'interest', and its role in learning (and wider life) was not part of the everyday dialogue between teachers and students. On a more positive note, even though students were often discussing the importance of getting a high grade so they could go on to further study of science there was an underlying impression that it was an interest in the subject that was driving the desire to continue in a scientific field.

The discussion in the following sections, will focus, in the main, on Situational Interest as a result of the strength of the correlation between Situational Interest and Individual Interest, along with the students' lack of clarity when discussing interest. Another reason for this focus is that, on a day-to-day basis, teachers have more opportunity to influence a student's level of Situational Interest than their Individual Interest, which will develop over time and as the result of a high level of Situational Interest. Where appropriate, reference will still be made to Individual Interest; however, from this point on 'interest' should be taken to mean Situational Interest, unless stated otherwise.

4.6 Discussion: Factors which increase student interest in learning science

The model of interest proposed by Hidi and Renninger (2006) predicts that various experiences and/or events will trigger Situational Interest and support the progression of that interest towards Well Developed Individual Interest. The findings presented here support this idea and the strength of the correlations between the different Interest Factors indicate that it is a combination of factors which result in Individual Interest. In their discussion of what can be done to support the development of interest, Hidi and Renninger (2006) appear to downplay the role that a dialogue with others; the factor most strongly agreed with by all students.

The importance of the cognitive, as well as the affective, was highlighted by the findings presented here. Much of the discussion from student focus group interviews mentioned affective aspects of interest, such as enjoyment of learning, enjoyment of an activity or relationships with others, although the results of this study also lend support to the idea that interest contains a cognitive component beyond the emotional response to something being ‘fun’. Certainly, one group of students in the current study felt that if an activity was not supporting their learning it was frustrating and therefore reduced interest (see the quotations regarding watching videos, p. 145 and p. 156). Furthermore, the strength of agreement with the questionnaire items ‘when the teacher is knowledgeable’ and ‘doing well in tests and assignments’ (Student Questionnaire 1: Section 1) demonstrates that students are aware of the cognitive aspect of interest.

One focus of this research was to ask students about factors they believed would increase their interest in learning science, rather than factors which would support their learning or were effective teaching methods. Previous research has found that students feel that some teaching activities can be enjoyable even if they are not effective and vice versa. For example, in response to the Student Review of the Curriculum 75% of students felt that watching videos was enjoyable, but only 27% believed this to be useful and effective in helping them understand school science (Planet Science, Institute of Education and Science Museum, 2003). Interestingly, the same study found that 64% of respondents felt class discussions and debates were enjoyable as well as 48% of students agreeing that these were the most useful and effective teaching method. When both the cognitive and affective aspects are accounted for these findings are in line with *Learning from others* being the Interest Factor which the students in this study agreed with most strongly.

Control and *Personal endeavour* were the second and third, respectively, most strongly agreed with Interest Factor for all groups of students and their importance is supported by previous research into autonomy-supportive classrooms which found that students' perceptions of the autonomy afforded to them significantly correlated with their interest in learning (Deci, 2015; Reeve and Jang, 2006). These Interest Factors contain statements that are the most similar of any two factors, although there are subtle differences in the component statements. *Personal endeavour* has a focus on learning, feedback and achievement, which is not found in *Control* and as Fisher (1978) discusses, although increasing understanding can have some influence on interest development, it is the experience of self-determination which has greater impact on developing and maintaining interest. Although these are two out of the three Interest Factors that students have agreed with, the data presented in Section 5.1 suggest that the students also view the teacher as having an important role in structuring each lesson to provide a framework which allows the student to take control of their work and thus support *Personal endeavour* and *Control* from the individual students' perspectives.

Overall, the students in this study were ambivalent about the importance of *Puzzles*, a view which does not support Mitchell (1993) who concluded that puzzles were an important factor in supporting the development of student interest. However, the qualitative data, collected during lesson observations and focus group interviews, presented above suggest that the students have increased Situational Interest when asked to solve different types of puzzles. This discrepancy could be a result of a lack of precision in the questionnaire statements, such as 'doing mind teasers', leading students to struggle to understand what sort of activities these may be and thus resulting in them being disinclined to rate such activities as increasing interest, even though their Situational Interest is triggered when students are actually undertaking the activities in lessons. Furthermore, differences between the questionnaire responses and the behaviours observed could have arisen as students may not necessarily see puzzles as relating specifically to learning science; therefore resulting in a reduced perception of their interest value.

Models and *Modelling*, both physical and cognitive, are a fundamental part of scientific endeavour and developing understanding. In Chapter 6, I will discuss how they may be used in the classroom. Here, however, it is worth mentioning that it became clear from Stage 2 of the research that models were considered by students to be physical artefacts. Although cognitive models were used in lessons they were referred to as 'models' neither by teachers nor students; rather, they were viewed as another piece of knowledge to be learnt. These findings, and the focus on the descriptive rather than explanatory or predictive nature of models, are consistent with previous research into the role of models and modelling in science education (for example, Grosslight *et al.*, 1991; Van Driel and Verloop, 2002). It is therefore difficult for students and for teachers to judge the impact of students both using and developing models on their interest level. A further limitation is that, as with *Puzzles*, students may have differing levels of experience of teaching that involves the use of models and modelling which would affect their ability to judge any impact that these activities would have on their interest level.

Paradoxically, the Interest Factor which focuses on developing students' understanding of science, *Exploring science*, is the factor which students were the most ambivalent about; with it scoring lower than the other Interest Factors. This finding may be better explained by considering it in light of the interest levels reported by students. Although a small majority of students were interested in science around 50% of them recorded a score between -6 and +6, from which it can be inferred that they would be likely be neutral towards the component statements of *Exploring science*. Of the remaining students, just over twice as many scored +7 to +26 as scored -7 to -26. If it assumed that those with the more positive scores would agree and those with more negative scores would disagree with *Exploring science*, this would result in a mean score of around neutral (0.085). Observations during Stage 2, however, did not appear to mirror this result. As observed by myself, and as reported by teachers, students frequently asked questions during their science lessons. These questions were often off topic and sometimes a little abstract but usually were related to some aspect of science, and generally based in the subject or domain of the particular lesson. The frequency of these questions, and the number of students who asked them, suggested that the mean score for *Exploring science* would have been higher. One possibility for this discrepancy is a mismatch between the curriculum content, which students had in mind when answering Student Questionnaire 1, and the content of the questions they were asking. Alternatively, they may not really have been interested in the answers to these questions and were just using them as a distraction technique!

Understanding the Interest Factors

The six Interest Factors, together with practical work, have an important role in developing student interest and, given the findings of this research, teachers should consider how they are used in lessons. In particular, since students believe that three of the factors: *Learning from others, Control* and *Personal endeavour*, increase their interest in learning science it would be prudent to consider how these can be incorporated into lessons most effectively. A theme common to all of the Interest Factors, but these three in particular, is that of the students feeling that they are facing an appropriate level of challenge.

Challenge is a difficult concept to concretize on an individual basis but is a theme which can be seen to pervade all of the Interest Factors. The importance of having an appropriate level of challenge to increase student interest is made explicit through the components of *Personal endeavour, Control* and *Modelling. Exploring science* and *Puzzles* have a challenge element by their very nature. Furthermore, the student responses during focus group interviews suggest that one of the reasons *Learning from others* scores so highly is the ability of group work to provide an appropriate level of challenge as peers can support each other in their learning, even if they are not necessarily within an individual's friendship group. Peer relationships are, by their very nature, different from adult-child relationships in that they tend to have higher levels of equality and mutuality; the discourse flows in multiple directions and is "extensive, intimate, and connected" (Damon and Phelps, 1989, p. 10).

Working with peers can therefore provide the support required to develop understanding, albeit in a less intimidating setting, since peer relationships are usually more equal with regards power balance. I am also proposing that peers may have a better understanding of the difficulties faced when learning new concepts as they have faced the challenges more recently than the majority of teachers, who can (generally) be presumed to have a mastery of the content they are teaching. Peers may, therefore, have the potential to provide more meaningful assistance to each other and allow for individuals to develop understanding through 'imitation', as used by Vygotsky, of more accomplished students (Chaiklin, 2003). These features of peer relationships mean that working within peer groups may allow students to feel more secure in asking questions or expressing opinions and can work to transform the task from 'intimidating' and 'personally threatening' to 'challenging' with "mistakes [seen as] amusing" (Damon and Phelps, 1989, p. 13) and thus support the transformation of interpersonal processes into intrapersonal processes (Vygotsky, 1980). However, if students feel they are working with, or next to, students who are much more able than they themselves are, they can perceive an imbalance of power that can result in a negative effect on learning. An imbalance of power in a relationship may also reduce interest in learning by failing to provide "optimal challenge" (Deci, 2015, p. 50) as students could feel that there is too large a discrepancy between their understanding and the activity or ideas they are being asked to master. It is therefore important, as Blatchford *et al.* (2003) discuss, to consider peer relations within a classroom and to plan for student-to-student interactions, and associated activities, as well as the interactions between teacher and student.

In summary, planning for the correct level of challenge is vital for supporting student interest and learning; however, it is difficult to nail down what 'challenging' is, and even more difficult to plan activities tailored to having the correct level of challenge for individual students in a large secondary science class. The Interest Factors presented above may help this planning in presenting a framework for teachers to work from by providing opportunities for students to shape their own level of challenge for *Learning from others, Control, Personal endeavour* and *Exploring science*, or by using specific strategies to increase challenge and develop the way students consider scientific ideas for *Puzzles* and *Modelling.*

A second underlying theme, emerging from the students' responses and behaviours during both Stage 1 and Stage 2 of the research, is that of 'active engagement'. During science lessons this is often taken to mean 'practical work'. Although this term encompasses a whole range of different activities it will be used to refer to the following: 'carrying out investigations', 'following procedure' and 'fieldwork' in line with the definition given by the majority of teachers (SCORE, 2008). Although practical tasks have the potential to support the development of interest, the data from my investigation are, for the most part, in line with the conclusions of previous research (Abrahams, 2009; Toplis, 2012) that although practical work may be considered enjoyable and trigger Situational Interest for students it rarely contributes to the development of Individual Interest. One explanation may be that practical work activities often fail in their objective, described by Tiberghien (2000) as trying to help students make links between the domain of objects and observables and the domain of ideas, due to lack of planning as to how students will make the links (Abrahams and Millar, 2008). Furthermore, lessons involving practical work often only focus on the related science content rather than the underlying investigative skills such as planning and analysis (Abrahams and Millar, 2008) and therefore students do not feel a sense of achievement or progress, nor do they have an understanding of the purpose of the task. Evidence from both previous research (Hidi and Renninger, 2006) and the data presented here highlights that the development of interest requires both a sense of achievement and an understanding of purpose (*Control / Personal endeavour*).

Practical work, however, is not the only activity which involves active engagement and the students who participated in this research expressed the view that any activity that involved 'doing something' was more interesting that 'just sitting and listening'. This finding is supported by previous research; for example, Shernoff *et al.* (2003) found that students were more engaged and interested in tasks requiring their input than listening to lectures or watching videos. Shernoff *et al.* (2003) also found that interest was increased when students felt that the level of challenge was appropriate to their skill level and when they had a sense of autonomy, which is consonant with the correlations between the Interest Factors reported here.

The role that the specific subject content plays in influencing student interest could explain the level of ambivalence seen with regards the students' responses to the Interest Factor *Exploring science*. Although, for reasons presented in Section 2.7, this research has endeavoured to avoid discussions regarding which domains and subjects were most interesting (Häussler and Hoffmann, 2000) students referred to this during the interviews and so it is an issue which cannot be ignored completely. Students may have answered the statements relating to *Exploring science* whilst considering what level of increased interest they gain from discussing some specific areas of science alongside a lack of interest in discussing other specific areas of science, therefore being more neutral in their answers to this factor than to other factors.

In line with previous research (for review, see Jenkins, 2006) it became clear throughout the focus group interviews and lesson observations that there are some areas of the school science curriculum that some students are simply not interested in. The students, for the most part, could not give specific reasons for this lack of interest, although there were some instances where students referred to a lack of high quality teaching as their reason for not working hard in a lesson which in turn reduced their interest in the content material. It was noticed, however, that when students are discussing their interest, or lack thereof, they often generalise from subjects to domains when they are discussing general dislike / disinterest e.g. they say they do not like ‘physics’ rather than they do not like ‘forces’. However, students were more subject specific when discussing their interest if they held a general interest for the domain e.g. they may like ‘biology’ but will also say they do not like ‘mitosis and meiosis’. These types of responses suggest that it may be possible to support students in developing more positive attitudes towards science, but not necessarily increase their interest, through supporting them to identify where their interest lies and which aspects of each domain they are interested in, for example, if they can identify that they find ‘forces’ interesting they may be encouraged to feel more positive about ‘physics’ as a whole.

4.7 Discussion: Purpose Factors

The findings from Student Questionnaire 1 show that students believe that the two main purposes of learning science GCSE are for *Professional Relevance* and *Developing knowledge*. Students are ambivalent about whether or not there is any role for developing *Social relevance* and *Personal relevance* as part of their learning science. The Purpose Factors identified here reflect, for the most part, purposes identified in existing literature but what is highlighted in the findings presented here is how the students group the components. For example, *Personal relevance* includes aspects of three of the arguments for learning science presented by Millar and Osborne (2006): reliable and useful knowledge; democratic and cultural. Other components previously cited, such as the purpose of increasing awareness of different professions involving science (Van Aalsvoort, 2004a), were not referred to by students at any point during the research.

Professional relevance is the most strongly agreed with purpose factor and the factor which was emphasised most explicitly in all the qualitative data collected. These findings are concerning and confusing as these students appear to have it firmly set in their minds, at the age of 14, that the purpose of the next two years of study is to prepare them for their career or to have a qualification certificate, echoing the findings of previous research in this area (Planet Science, Institute of Education and Science Museum, 2003). This could be interpreted as learning as a means to an end, and that once they have achieved that end they will stop learning, unless it is required for later career progression. This finding is not entirely surprising given the emphasis that is placed on GCSE results at national, school and individual levels. In a study of over 1600 students Denscombe (2000) found that GCSEs were viewed as a means to an end with students experiencing stress as a result of caring what grades they would achieve in the examinations. They go on to conclude that this stress "reflects the awareness that performance in terms of GCSE results can have far-reaching consequences for their futures, can shape their destinies in a very real fashion" (Denscombe, 2000, p. 372), which is echoed by the students in the current study. It could be argued that *Professional relevance* sits firmly within the realm of external motivation rather than being about interest and internal to the students. The motivation to achieve a goal and viewing the purpose of the two years of study as achieving the qualification could have massive implications for these students in terms of whether or not they become life-long learners.

The relative levels of students' agreement with the Purpose Factors was reflected in the extent to which each was communicated to students during the observed lessons and in the references students made with regards Purpose Factors during the focus group interviews. Students agreed that *Professional relevance* and *Developing knowledge* were purposes of learning science but were ambivalent regarding *Personal relevance* and *Social relevance.* One explanation for why *Social relevance* did not feature highly during lesson observations is that it is external to the students and mainly describes purpose at a national level: priorities for the government. On examination of the component statements for the Purpose Factors it could be argued that *Social relevance* is the mirror to *Professional relevance*, albeit at a general population level rather than an individual level. Therefore, there may be fewer references to *Social* relevance in lessons as the teachers want to treat students as individuals rather than make more sweeping statements.

From the perspective of this thesis the most important factor is that of *Personal relevance*, as this is most closely equated with Interest, having both affective and cognitive elements. The low level of agreement with this factor is mirrored by the statement 'Because it is just so interesting' being ranked the lowest on the questionnaire and there is little reference made to this as being a purpose of learning science in any interviews or lesson observations. The differing levels of agreement with the Purpose Factors may reflect the level of explicit references to these in the science lessons that the students' experience. Previous research has found that a significant proportion of students (85%) feel that teaching of science is 'exam-led' (Murray and Reiss, 2005).

The relationships between Interest Factors and Purpose Factors

The students being continually exposed to messages regarding the importance of their GCSE qualifications, which is a consistent message presented to all students, could explain, at least in part, why the standard deviation levels are lower for the Purpose Factors than for the Interest Factors. Interest, on the other-hand, is an internal state that, although externally supported, is rarely discussed explicitly with regards to what it is, how it develops and its importance to learning. The individual nature of interest, and the lack of regular or consistent messages regarding it, go some way to explaining the higher level of variation in student responses when compared to the Purpose Factors.

The correlations between the Interest and Purpose Factors suggest that students view *Personal relevance* as relating to their *interest* in learning science more strongly than to *reasons* for learning science. These findings reflect, in part, those of Swarat, Ortony and Revelle (2012) who found that the activity students undertook, rather than the purpose, accounted for the variance in student interest. Debacker and Nelson (2000), on the other hand, found strong correlations between the three types of value outlined below:

> Intrinsic value is a measure of one's personal enjoyment or satisfaction from engaging in tasks in the science domain. Utility value is the degree to which students value science for its usefulness in a future endeavour. Attainment value is the importance one places on accomplishments in the science domain. (Debacker and Nelson, 2000, p. 247)

Furthermore, students often refer to career aspirations when discussing their interest in lessons both with regards to science and other subjects. At times though, students express the view that they would like to pursue a career as they have a strong interest in the field and on other occasions they state that their desire to work in a particular profession increases their interest in science lessons. Such views suggest a link between *Exploring science* and *Professional relevance* which is not reflected in the responses students gave to the questionnaires. The link that students in the North of England, although interestingly not in the South of England, make between their interest in learning science and their career aspirations was also noted by Osborne and Collins (2000).

4.8 Key conclusions

This chapter has presented the findings regarding students' levels of interest and the factors they believe increase their interest in learning science, together with the factors which students believe to be reasons for learning science at GCSE level. These three areas provide insights into students' attitudes towards science lessons as well as highlighting the relationships between existing interest levels and the extent to which students feel that external factors can increase their interest in lessons.

At the start of the GCSE course more students (14 year-olds) were interested in science lessons (Situational Interest) and science in general (Individual Interest) than were disinterested. There is a very strong relationship between both types of interest.

Six Interest Factors were generated from the questionnaire, three of which – *Learning from others*, *Control* and *Personal endeavour* – students believe increase their interest in learning science. By carefully incorporating these factors into classroom practice it may be possible to increase student interest in science lessons. These factors appear to be underpinned by the importance of appropriate levels of challenge, autonomy and active engagement in learning which could be enhanced through the effective use of practical work, modelling (both theoretical and physical) and puzzles.

Four Purpose Factors were generated but students were ambivalent about the role of *Personal* and *Social relevance*, only agreeing with *Professional relevance* and *Developing knowledge*. The strength of agreement with these two factors reflected the emphasis placed on them by teachers during lessons, by the school ethos and by the wider society, highlighting the influence that others have over students' beliefs. It is therefore important, if there is a need for students to understand the wider aims of science education, for greater emphasis to be placed on these wider aims by teachers and others who have influence over students.

Although these conclusions provide a starting point for considering how students can be supported in increasing their Situational Interest and thus developing Individual Interest, the conclusions reached here only reflect the student population used in this study. As all teachers are aware, there is a no 'one-size-fits-all' solution to any aspect of pedagogy. Chapter 5, therefore, considers the data collected with regards to differences between the students from different schools, between male and female students and between students placed in different ability sets. Additionally, given the extent to which the role of the teacher has been highlighted here, Chapter 5 includes a comparison between the student responses and those of their science teachers with regards to levels of agreement with the Interest and Purpose Factors.

Chapter 5: A Comparison of groups of students' and teachers' beliefs

The assessment of students' interest levels and the generation of the six Interest Factors and four Purpose Factors, in Chapter 4, allowed comparison of responses from different student groups, based on which school they attended (Section 5.1), their ability group (Section 5.2) and their gender (Section 5.3). The similarities and differences between these groups of students are presented with respect to their interest level, the level of agreement with each of the Interest Factors and the level of agreement with the Purpose Factors. Similarities and differences between the beliefs of students and their teachers, based on data from Student Questionnaire 1 and the Teacher Questionnaire, administered in Stage 1 of the research, are also examined (Section 5.4). After a discussion, this chapter closes with a consideration of the implications the findings may have for classroom teaching and the possibility of increasing student interest in science lessons. All of the data tables, which accompany the figures in Chapter 5 can be found in Appendix 9.

5.1 Comparison of student responses when grouped by school

Students from four different schools completed Student Questionnaire 1. As described in Section 1.4: Box A all four schools had some similarities, for example, all are in the North West of England, although they varied in terms of size and range of science courses delivered to students between 14-16 years of age.

Figure 5.1 shows the student scores for the two types of interest in each of the schools. There is no significant difference, based on the 95% confidence limits, between the Situational and Individual Interest scores, in any of the schools. This is as might be expected from the strength of the overall correlation (see Figure 4.2, p. 121). Although there are minimal differences, it is noteworthy that the variation between schools is greater than within the schools. Furthermore, the students from School A have significantly lower Situational Interest than the students from the other three schools and significantly lower Individual Interest than School D students. Overall, these results support the correlation between Situational Interest and Individual Interest, as the rank order of schools is the same for both types of interest, and show that students in School A have interest levels which are below average when compared with the rest of the student participants. The lack of Situational Interest reported by students from School A is particularly marked with a mean score significantly lower than the students from the other three schools.

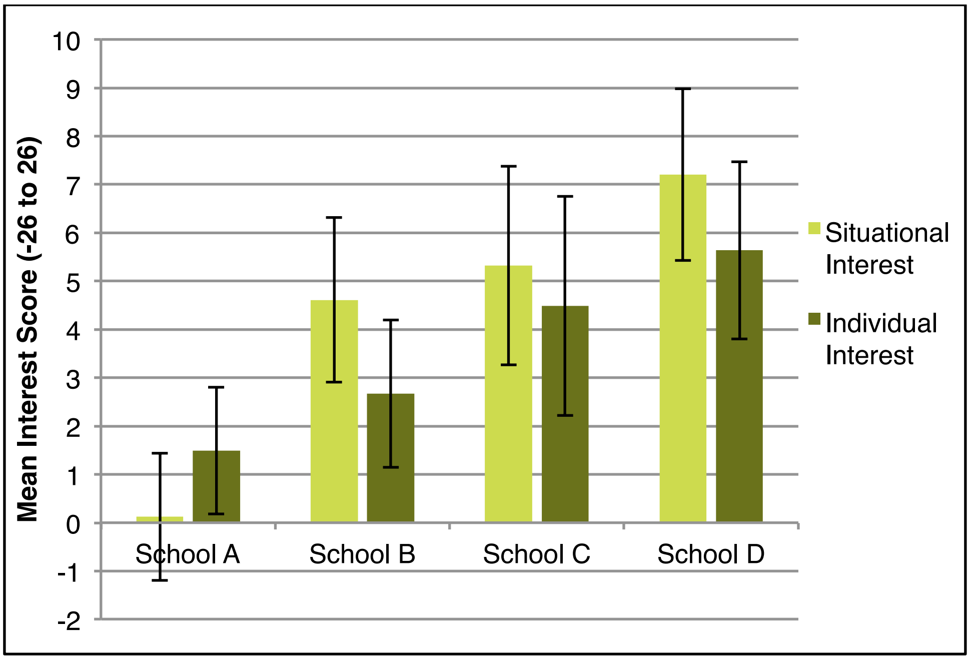


Figure 5.1 Mean Situational Interest and Individual Interest scores from each of the schools (potential range of scores is from -26 [very low interest] to 26 [very high interest]).

The differences in student interest levels between schools (see Figure 5.1) display similar patterns to the strength of agreement each school had with the Interest Factors, identified in Section 4.2. For the majority of the Interest factors, the strength of agreement follows the same pattern of A<B<C<D, where School A has the lowest score and School D has the highest score, as shown in Figure 5.2. There are few significant differences in the strength of agreement with the

Interest Factors of students from the different schools, though the students from School A reported significantly lower levels of agreement with *Learning from others, Modelling* and *Exploring science* than the students from the other schools.

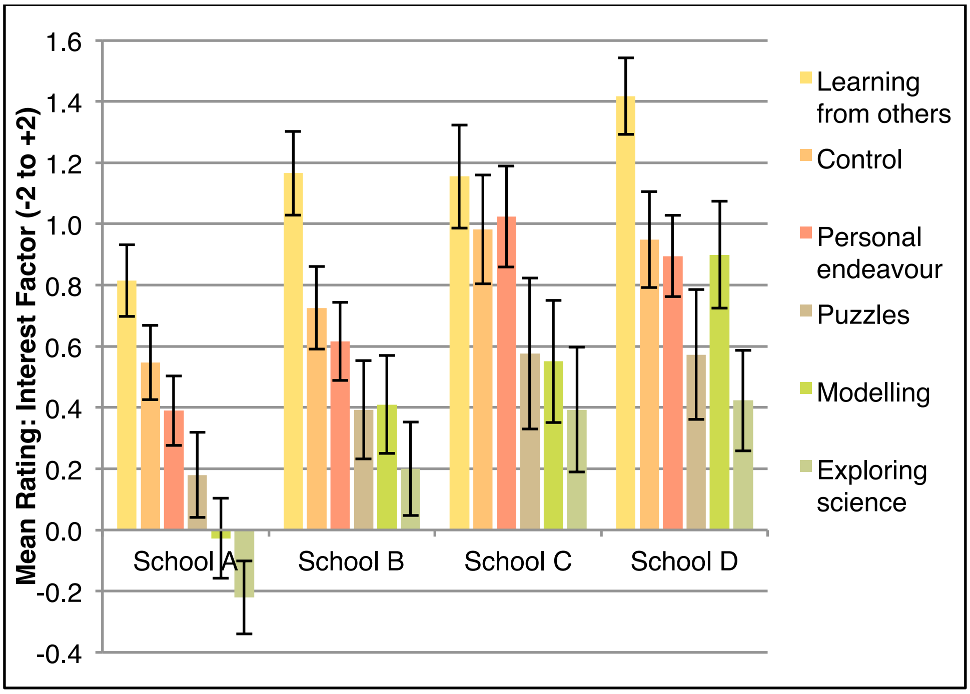


Figure 5.2 Mean strength of agreement with the Interest Factors from each of the schools (1.00 = agree, 0.00 = neutral, -1.00 = disagree).

Within each school the same general trend in seen, although it varies in magnitude, for the strength of agreement with each of the Interest Factors. The most notable exception to this is *Modelling* which has a lower score than *Puzzles* in School A, similar score to *Puzzles* in Schools B and C and a higher score than *Puzzles* in School D.

In line with findings presented in Section 4.2, students in all schools show agreement that *Learning from others* and *Control* increase their interest in science lessons and students in all schools appear to be ambivalent about the role *Exploring science* has in increasing interest levels. Although all classes are ambivalent, the negative response to *Exploring science* from School A is interesting given that these students asked a large number of curiosity questions in the lesson observations, all of which took place in this school during Stage 2 of this study.

The students from School A provided a distinctive set of responses, when compared to the other schools in the study, as they have the broadest range of responses. The other three schools have at least four factors with similar scores, with School C having the most homogeneous set of responses. A similar pattern is reflected in the extent to which the students from the different schools agreed with the Purpose Factors generated in Section 4.3, although, as shown in Figure 5.3 there are few significant differences between the mean scores for the Purpose Factors from each of the schools. Most obviously, School A agrees significantly less with *Developing knowledge* than Schools C and D, and *Personal relevance* than Schools B and C; the latter of which is not surprising given the correlation between interest score and *Personal relevance* and School D agrees significantly less with *Social relevance* than Schools B and C.

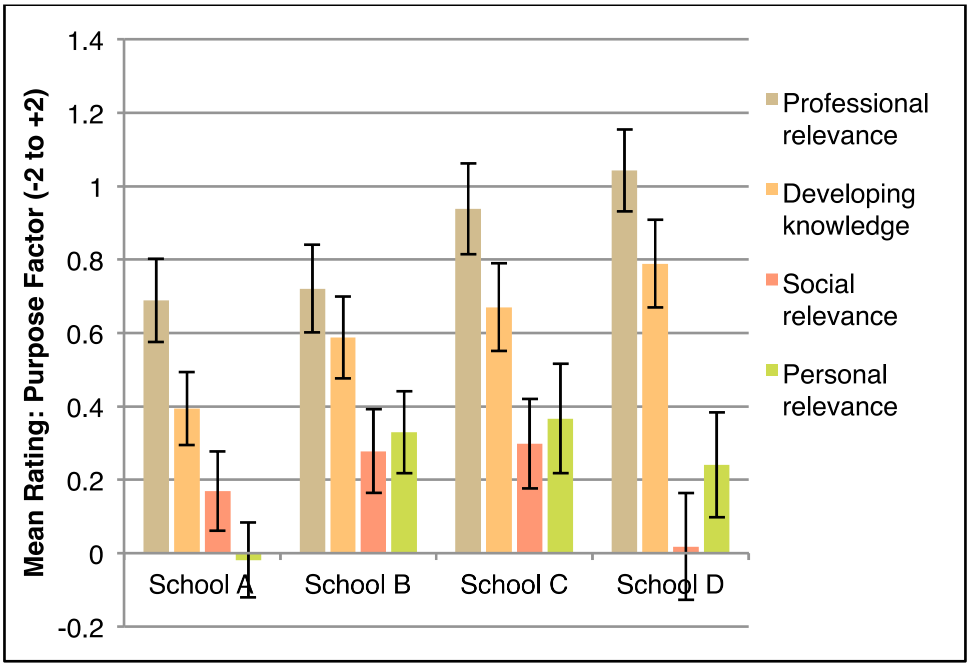


Figure 5.3 Mean strength of agreement with the Purpose Factors from each of the schools (1.00 = agree, 0.00 = neutral, -1.00 = disagree).

All of the schools show patterns of strength of agreement with the Purpose Factors that are similar to the overall pattern of responses, agreeing significantly more with *Professional relevance* than with *Developing knowledge*, which is, in-turn, higher than the agreement with *Social relevance* and *Personal relevance*. The latter two factors show no significant difference. The only exception to this is where School B students have no difference in their level of agreement with *Professional relevance* and *Developing knowledge*. Students at all schools are ambivalent with regards the belief that they will be learning science for the next two years because it has *Social or Personal relevance* while students at School A are, in addition ambivalent about *Developing knowledge* being a purpose of their science studies at GCSE.

Given the strength of correlation between students' interest scores and their level of agreement with *Personal relevance* it could be expected that School D would have the highest level of agreement with this Purpose Factor, however, this is not the case, as Schools B, C and D show no significant difference in their level of agreement with *Personal relevance.*

Who is responsible for influencing interest?

As well as measuring interest level Student Questionnaire 1: Section 3 included two statements to assess students' beliefs about the roles their teacher and they themselves had in supporting interest. One statement asked about the extent to which students saw a link between the amount of effort they put into the lesson and how interested they were in that lesson and another statement was used to assess the extent to which they felt that getting them interested in a lesson is part of the teacher's role. The statements were:

- I am more interested if I put more effort into the lesson
- Teachers should make the lessons interesting.

These statements were scored in the same way as the rest of the responses and mean scores were calculated for all students (see Table 5.1) and the students from each of the schools (see Figure 5.4). The mean results for all students (see Table 5.1) suggest that they believe that it is the teacher's role to influence the students by making the lessons more interesting and that students also agree, albeit less strongly, that if they put more effort into the lessons they find them more interesting.

Table 5.1 Student responses to who has more of an influence on increasing student interest during lessons (-2 strongly disagree; -1 disagree; 0 neutral; 1 agree; 2 strongly agree).

	Mean	**95% confidence limits**
Student's influence	0.638	±0.092
Teacher's influence	1.022	±0.086

Students from School A had, on average, views which were significantly different from students in the other three schools (see Figure 5.4). School A's students agreed significantly more strongly with the statement 'Teachers should make the lessons interesting' than 'I am more interested if I put more effort into the lesson', whereas the other schools reported no such difference. Furthermore, School A students were the only group to be ambivalent with regards the role that the level of effort they put into lessons plays in supporting their interest levels. These differences cannot be explained easily in terms of student demographics as the students from School B cover the same ability range and all four schools have a similar ratio of female to male students. There are no significant differences between the levels of agreement with the statement 'Teachers should make the lessons interesting' from students from each of the schools.

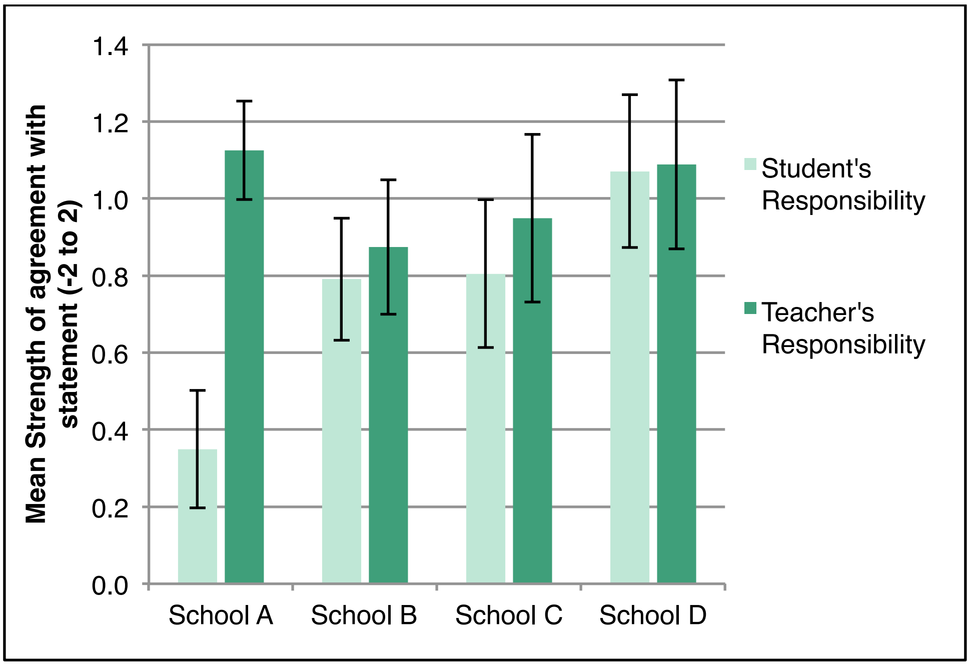


Figure 5.4 Student responses, by School, to who has more of an influence on increasing student interest during lessons (-2 strongly disagree; -1 disagree; 0 neutral; 1 agree; 2 strongly agree).

During the focus group interviews, conducted in School A during Stage 2 of the research, students were very definite in their belief that teachers have a role to play in engaging them in the lesson through structuring learning appropriately and how they manage the behaviour of the students in the class.

> S1: I don’t like physics so
>
> S2: No
>
> S3: Me either
>
> HD: Why not?
>
> S1: So Miss x you know is gone=HD: right=((other students laughing)) {what?} {just Miss x} she’s gone so we’ve had like four different, what do you call them . . . relief teachers.
>
> HD: Er, supply teachers yeah
>
> S1: And- =Student 4: we’ve had that with Mrs Y as well=
>
> S1: And some of them are just really annoying because they don’t even control the class and so most of the time we so we don’t even get any work done and we don’t learn anything. (7 Feb 2013, Student Focus Group Interview)

A similar view was expressed by a different group of students during a different focus group interview:

> S1: In some aspects I prefer like biology and chemistry because I understand it more whereas I don't really like physics because at the beginning of the year, Year 10, we didn't have a teacher so we didn't like, kind of, sit down and start work straight away so I think it was like if we had settled down right at the start.
>
> S2: The interest was kind of gone within two weeks of Year 10. (1 May 2014, Student Focus Group)

However, the students often lacked internal consistency with their statements as S1 also said "I don't think that it is the way that it is taught that makes it interesting" during the same focus group.

Students also need to feel confident in their teachers, and, so far as maintaining their interest goes, the teacher's performance in leading the lesson is presented by the students as being more important than the topic being studied:

> S1: [She] didn't really understand it though did she? There was something about like how atoms are like formed and that and someone asked her like how they know that and she just said there was evidence (. .) but she couldn't like say what the evidence was so she's just going "oh there's evidence they've proven it, there's evidence".
>
> HD: So how did that make you feel in terms of interest in the lesson?
>
> S1: It kind of made me feel that she didn't know what she was talking about ().
>
> S2: Yeah.

S3: If a teacher doesn't understand then it's dead hard for them to make us understand if they don't actually know why they are telling us it. (7 Feb 2013, Student Focus Group Interview)

Surprisingly, there is no significant relationship between the responses individual students gave to the two statements regarding who is responsible for encouraging interest in the lesson; teachers or themselves (see Table 5.2). However, there is a significant ($p<0.0005$) positive correlation between a student's strength of agreement with the statement 'I am more interested if I put more effort into the lesson' and both their Situational Interest and Individual Interest scores. This implies that students are aware of the link between their input into their learning and their interest in the subject. This conclusion is further supported by the significant negative correlation between students' strength of agreement with 'Teachers should make the lessons interesting' and their Individual Interest score and Situational Interest score ($p<0.005$ and $p<0.025$ respectively). However, this negative correlation could be interpreted as the students who have a higher level of interest in science believing that the teachers already make lessons interesting.

Table 5.2 Calculated values and significance levels for Pearson's r tests between agreement with each of the responsibility statements and students' scores for Situational and Individual Interest. (^ not significant, *$p<0.0005$, § $p<0.025$).

	Student's Responsibility	**Teacher's Responsibility**
Teacher's Responsibility	0.027^	
Situational Interest	0.479*	-0.146*
Individual Interest	0.449*	-0.110§

The correlation between students agreeing that the effort they make in lessons relates to their interest and the interest scores reported supported the differences between School A and the other schools; School A students have lower interest levels and are ambivalent about their role in developing their own interest.

5.2 Comparison of student responses when grouped by ability set

As explained in Section 3.3, the students in this study, regardless of the school attended, were placed in classes, ‘sets’, based upon their prior attainment with the most able students in set 1 and the least able students in set 4.

The relationship between the ability set of a student and their interest levels is clearly illustrated by Figure 5.5. There are significant correlations between the ability set a student is taught in and both their Situational Interest score (Pearson’s $r = 0.275$, $p<0.005$) and their Individual Interest score (Pearson’s $r = 0.299$, $p<0.005$). Furthermore, students in each ability set have a significantly higher mean Situational Interest score than the students in the ability sets which are two or more sets below them. This is also true for the mean Individual Interest scores.

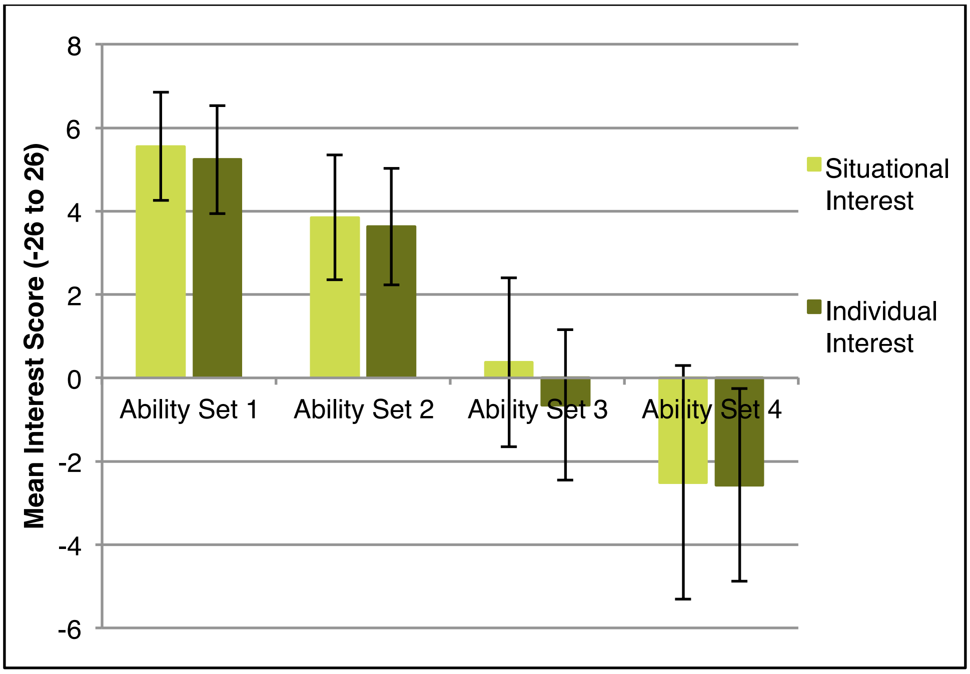


Figure 5.5 Student scores for Situation Interest and Individual Interest when grouped by ability, based on the ability set the student is taught in at their school (potential range of scores is from -26 [very low interest] to 26 [very high interest]).

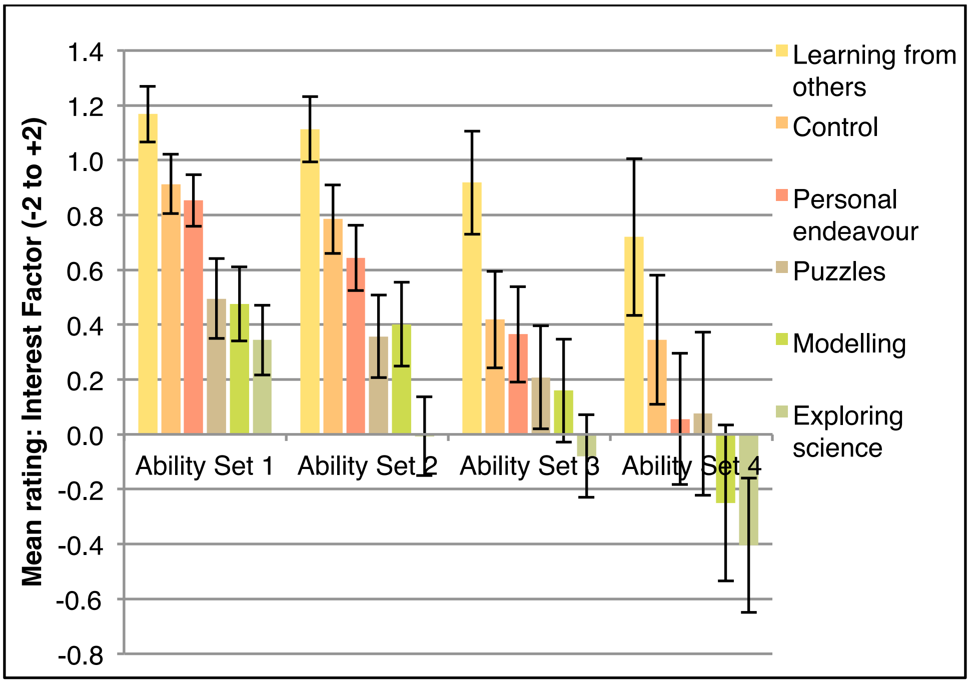


Figure 5.6 Mean strength of agreement with the Interest Factors from students in the different ability sets across all schools (1.00 = agree, 0.00 = neutral, -1.00 = disagree).

Comparison of Figures 5.5 and 5.6 shows a similar relationship between the levels of interest and strength of agreement with the Interest Factors of students in the different ability sets that is demonstrated by students from the different schools; the higher the level of interest, the higher the strength of agreement with the Interest Factors. This is particularly evident for *Personal endeavour* and *Exploring science* where each ability set has significantly higher mean scores than the ability sets two or more sets below it. In general, ability sets 1 and 2 show similar levels of agreement with each factor, as do ability sets 3 and 4, which suggests there is a larger divide between sets 2 and 3 than between other adjacent sets. This is exemplified by students in sets 1 and 2 agreeing with three out of the six factors and being ambivalent with regards the other three Interest Factors, whereas students in sets 3 and 4 are ambivalent about the ability of any of the factors to increase their interest apart from *Learning from others.*

Personal endeavour and *Exploring science* show the greatest variation in mean scores between the ability sets with set 1 students reporting mean scores 0.80 and 0.75 higher respectively than set 4 students. The least variation in agreement between the sets is for *Puzzles* and *Learning from others,* which only vary between the highest score, set 1, and the lowest score, set 4, by 0.42 and 0.45 respectively.

On examination of the strength of student agreement with the Purpose Factors (see Figure 5.7) a similar trend is seen in the data from each of the groups, regardless of their ability grouping, with *Professional relevance* being the factor most strongly agreed with. The differences between the ability sets are notable because, as with the Interest Factors, students in each ability set generally agree more strongly with each factor than students in the ability set below them. However, there are no significant differences between the responses from students in sets 1 and 2*.* The student responses for set 3 are significantly lower than those of set 2 for *Professional relevance, Developing knowledge* and the set 4 students also agreed significantly less than set 3 students with these Purpose Factors. Furthermore, students in ability set 1 have levels of agreement with all of the Purpose Factors that are significantly higher than those of the students in ability set 4.

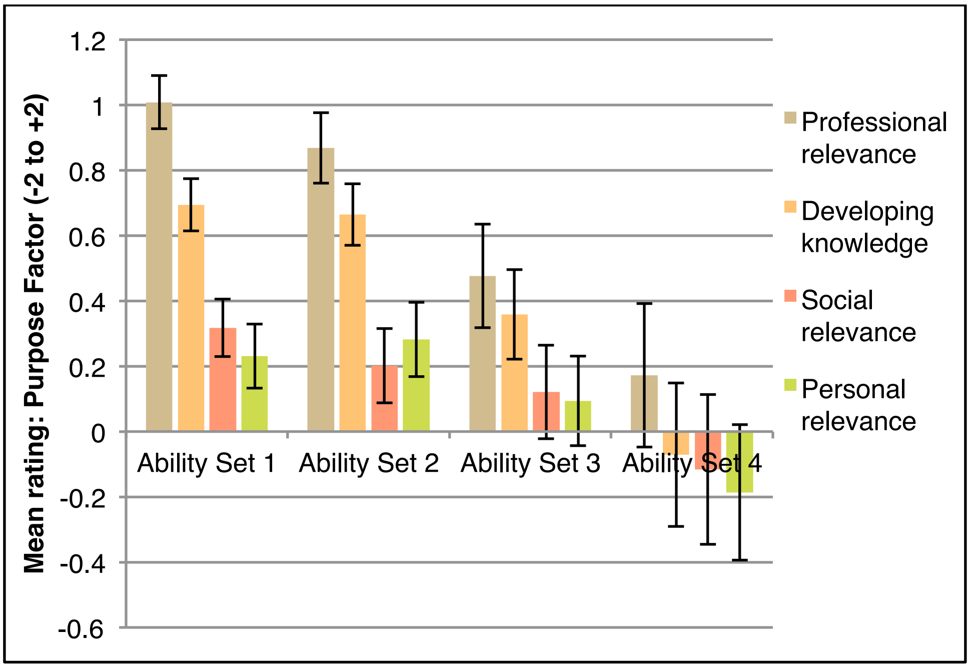


Figure 5.7 Mean strength of agreement with the Purpose Factors from students in the different ability sets across all schools (1.00 = agree, 0.00 = neutral, -1.00 = disagree).

The trends seen in Figure 5.7, where students in sets 3 and 4 are ambivalent about any of the factors being a purpose of their science lessons, were observed in the classroom and are demonstrated by student behaviours, as Mr T commented:

> With my set 4s I am constantly being asked “when are we ever going to need this”. (10 May 2013, Teacher Focus Group Interview)

It is clear from the data presented that there are significant differences between the attitudes of the students in the different ability groups with regards to their interest levels and strength of agreement with the Interest and Purpose Factors. There are few differences, however, between the beliefs of students from the different ability sets about who is responsible for developing interest. As can be seen in Figure 5.8 there are no significant differences between the level of agreement regarding student responsibility between any of the ability sets and the only significant difference between the levels of agreement regarding teacher responsibility can be found with set 2 students agreeing less than set 3 students. There is greater variation within the ability sets with students from sets 2, 3 and 4 all agreeing more strongly with ‘Teachers should make the lessons interesting’ than with ‘I am more interested if I put more effort into the lesson’.

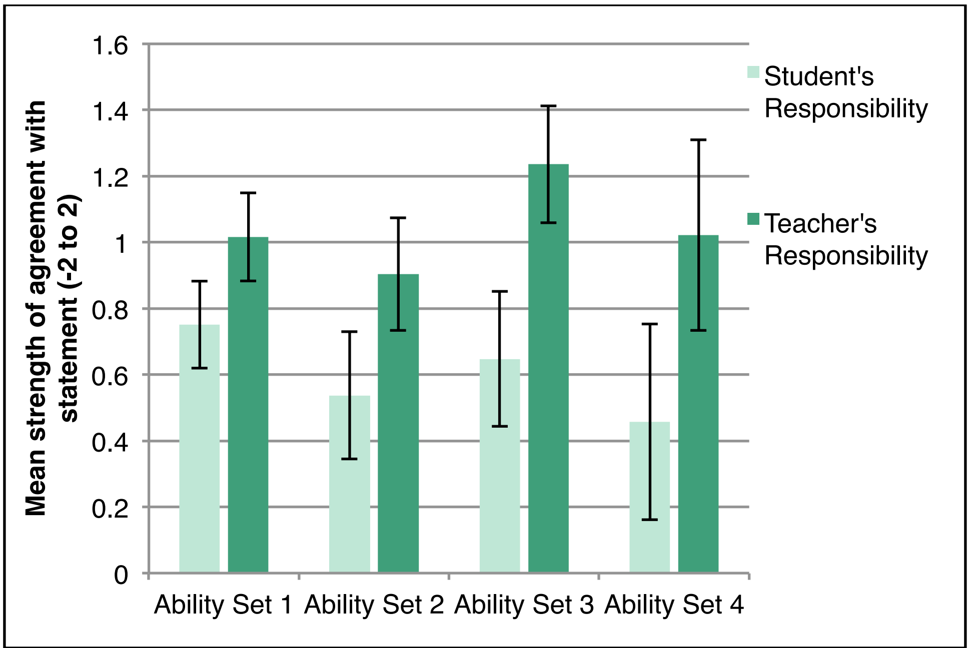


Figure 5.8 Student responses, by ability set, to who has more of an influence on increasing student interest during lessons (-2 strongly disagree; -1 disagree; 0 neutral; 1 agree; 2 strongly agree).

It is not possible to break this down by school and still reflect all of the ability groups since only two of the schools in the study returned questionnaires from all ability groups. It is, however, possible to compare the responses from School A students to the rest of the student participants (see Figure 5.9). This is a worthwhile comparison given the stark contrast between the interest levels of students in School A and the rest of the students.

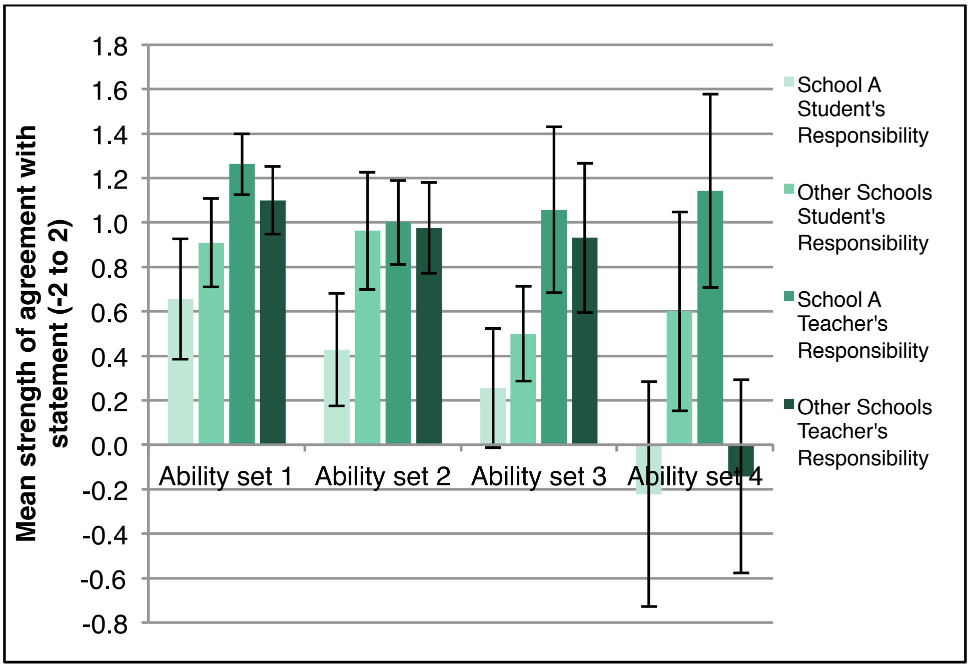


Figure 5.9 Student responses, by School and ability set, to who has more responsibility for increasing student interest during lessons (-2 strongly disagree; -1 disagree; 0 neutral; 1 agree; 2 strongly agree).

Again, there is substantial variation between School A and the other schools in students' beliefs as to who holds responsibility for increasing interest in science lessons. Most notably, School A students in all ability groups agree less with the statement 'I am more interested if I put more effort into the lesson' than the students from other schools with only set 1 students from School A actually agreeing, on average, this this statement. The pattern of responses from School A for students' responsibility mirrors the pattern of reported interest levels from students in the different ability sets (see Figure 5.5). In contrast to this, the majority of students in all schools, whatever their ability sets, show no significant differences between their levels of agreement regarding teacher responsibility. The exception is students from ability set 4, although this may be an artefact of only School A and School B providing data for set 4 students.

5.3 Comparison of student responses when grouped by gender

Gender differences in both attainment and engagement in science education are the subject of a substantial and important body of work and therefore it would have been remiss to omit an analysis of them here. Male students had higher mean scores for both Situational Interest and Individual Interest than female students, although, the mean scores were not significantly different between, nor within, each gender (see Figures 5.10 and 5.11).

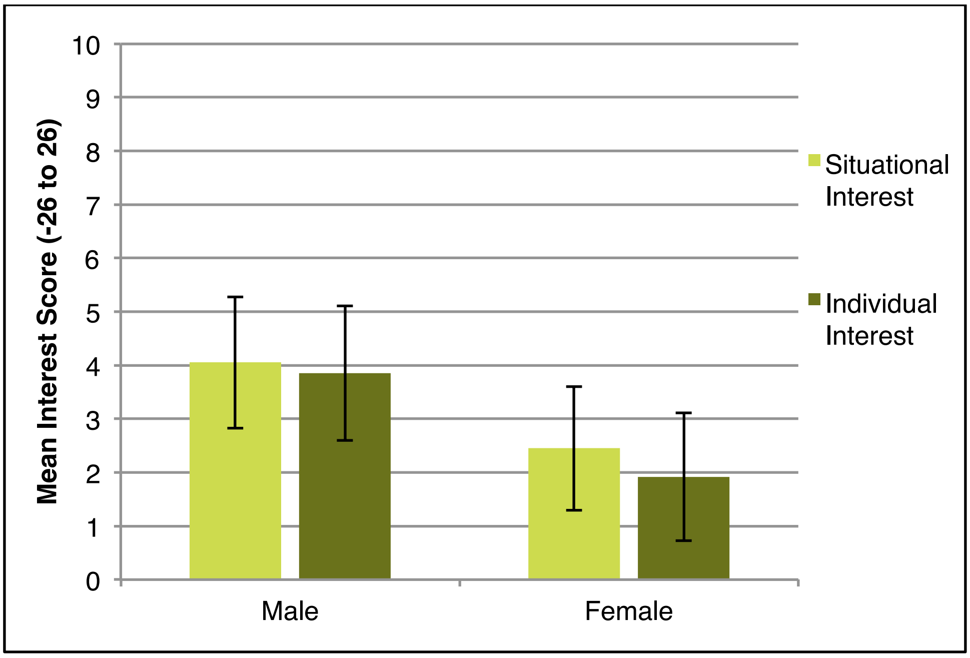


Figure 5.10 Mean scores for Situational Interest and Individual Interest for male and female students (potential range of scores is from -26 [very low interest] to 26 [very high interest]).

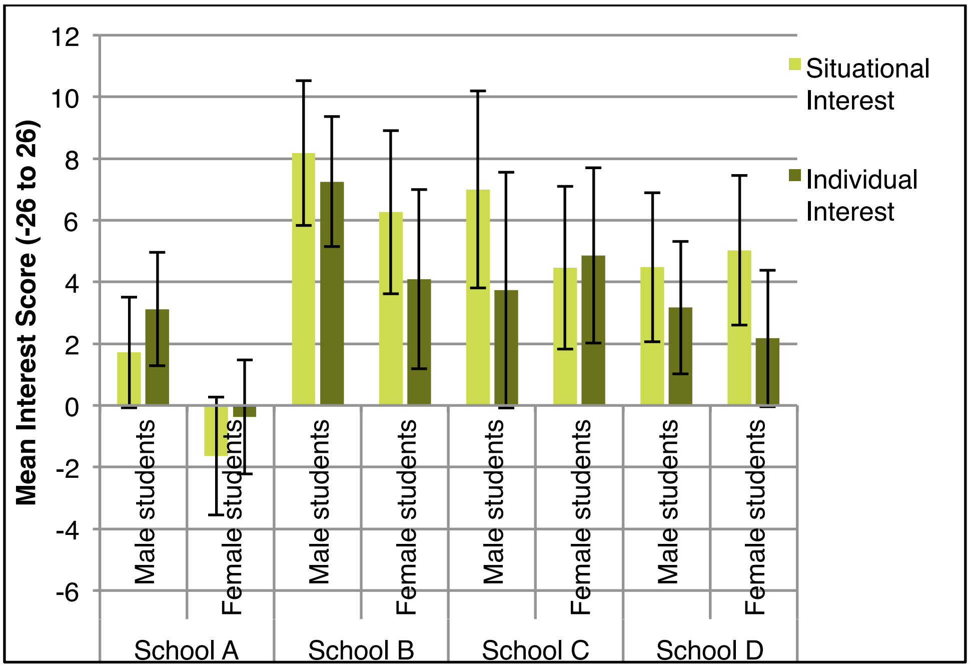


Figure 5.11 Mean scores for Situational Interest and Individual Interest for male and female students from each of the schools in the study (potential range of scores is from -26 [very low interest] to 26 [very high interest]).

Although these findings are not surprising they are notable when considered with the reported levels of agreement by students of each gender for the Interest and Purpose Factors. Given the trends presented for the students from different schools and different ability sets it would be reasonable to expect that male students would agree more strongly with both the Interest Factors and the Purpose Factors. The link between students' interest levels and their level of agreement with the Interest factors is emphasised as students from ability set 1 have the highest reported scores for each section of the questionnaire. Similarly, School A students have the lowest levels of interest and also the lowest levels of agreement with each set of Factors. However, as Figure 5.12 shows, female students, despite reporting lower interest levels, have significantly higher levels of agreement with *Control, Personal endeavour* and *Modelling* than male students. Male students do not agree significantly more than female students with any of the Interest Factors.

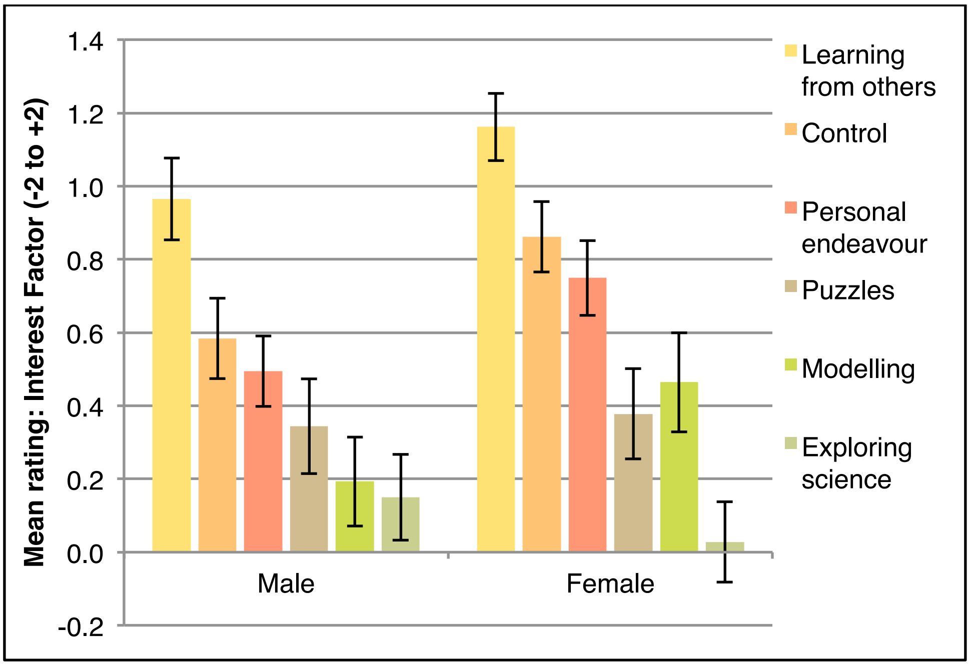


Figure 5.12 Mean strength of agreement with the Interest Factors from male and female students (1.00 = agree, 0.00 = neutral, -1.00 = disagree).

The reversal of the relationship between interest level and strength of agreement with the Interest Factors can also be seen for the Purpose Factors as female students agreed more strongly than male students that *Professional relevance* is a purpose of their science education (see Figure 5.13). However, unlike the differences seen between students from the participating schools and different ability groups, there are no other significant differences between male and female students with regards the strength of agreement with the Purpose Factors; both groups agree with *Professional relevance* and *Developing knowledge* and are ambivalent with regards *Social relevance* and *Personal relevance.*

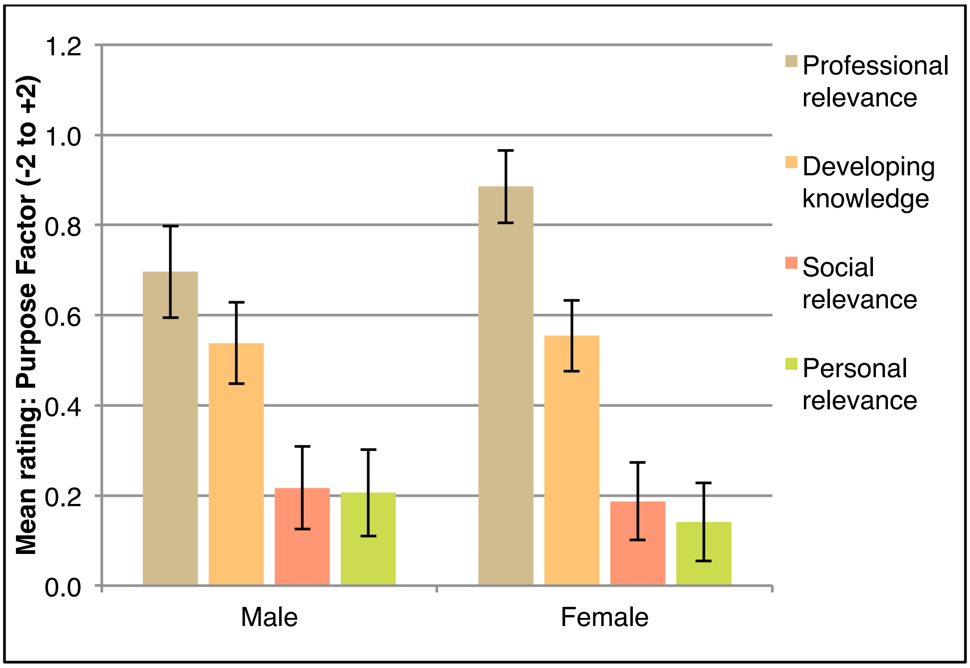


Figure 5.13 Mean strength of agreement with the Purpose Factors from female and male students (1.00 = agree, 0.00 = neutral, -1.00 = disagree).

5.4 Discussion: The differences in strength of agreement with the Interest Factors and Purpose Factors between different groups of students

The responses from students in different schools

The differences in Interest scores between schools could, to some extent, be explained by the differing composition of the samples from each school. Examination of Figure 5.5 suggests that ability grouping of the students can explain why the mean scores from Schools A and B, where students were from all four ability sets, are lower than the scores for Schools C and D, in which only students from the top two sets completed the questionnaire. However, this explanation does not shed any light on why the students from School A have significantly lower Situational Interest than Individual Interest, in contrast to the other schools where there is either no differences in the levels of interest (Schools C and D) or Situational Interest is higher than Individual Interest (School B). In addition, students from School A have the lowest overall levels of interest as well as the lowest levels of agreement with the Interest Factor *Exploring science* and the Purpose Factor *Personal relevance.* As such, the students from School A appear unique in their levels of interest and agreement with the Interest Factors and therefore merit further examination. I am aware that during the academic year preceding the students completing Student Questionnaire 1 there were a number of issues relating to the quality and consistency of teachers for some of these students. On a number of occasions, teaching from one member of staff was observed that would not have been regarded as appropriate by a student on an initial teacher education course. This member of staff taught two of the eight classes in this academic year and students reported, during Stage 2 of data collection, that lessons with this teacher had a negative effect on their interest in science.

The levels of agreement with the Interest Factors show similar patterns between the different schools, with only a small number of exceptions, with School A rating *Modelling* as significantly lower than the other schools and School D agreeing with *Modelling* significantly more than the other schools. One plausible reason for these differences is the range of teachers and teaching styles which the students will have experienced. A range of factors, such as school ethos, training experiences, a teacher's personality, will influence teaching style and thus the students' experiences of learning science. These experiences will then, in turn, impact on how strongly the students agree with each of the factors. For example, students may never have had the opportunity to use drama to model scientific ideas and so can only speculate on the extent to which it would influence their interest in learning science. A lack of familiarity could easily explain the variation in students' responses in the different schools to *Puzzles* and *Modelling*, the use of which varies greatly between teachers, depending on their preferred teaching styles. However, all students can be expected to have substantial experience of *Exploring science* and be able to respond without the need for conjecture and so another explanation is needed for the differences seen here. If a score greater than 0.5 is taken to indicate agreement with a factor none of the schools agree that, on average, *Exploring science* will increase their interest levels. Despite this, however, there is a large range of scores; School D students have an average level of agreement which is 0.644 higher than that of School A students (see Figure 5.2). The obvious explanation for this is the correlation between a student's level of interest and their level of agreement with all of the Interest Factors, although this still leaves open the question as to why School A students have such low levels of interest in learning science and is there anything which can be done to address this. This question will be addressed in more depth in Chapter 6.

The lack of differences between the patterns of each schools' agreement with the Purpose Factors may be explained by the consistency of the messages that students receive from teachers, and society more widely, and how these shape their understanding of the purpose of learning science. The focus of *Professional relevance* is embedded in school practice in a number of ways, one of the most explicit being the setting of, and reporting against, target levels and grades. During the first terms of their GCSE course, students in School A, and in the vast majority of schools, are presented with a list of target grades for their GCSE courses and teachers are asked to discuss these with the students. The policy of School A at the time these students entered Year 10 was to base a student's minimum target grade on the most probable FFT20[2] benchmark grade and then to further this discussion by asking students if they would like to set a personal 'aspirational target grade', a grade higher than the one given to them. This focus on target grades, both minimum and aspirational, early on in the GCSE course is an indication of a culture

[2] FFT20 stands for Fisher Family Trust benchmark predicted grades based on schools that made the top 20th percentile progress nationally (FFT Aspire, 2015).

which places a strong emphasis and high importance on examination performance and which permeates throughout the school.

As with the Interest Factors, the differences in the strengths of agreement that students from each school have with *Professional relevance* and *Developing knowledge* can be explained by the differences between the samples of students surveyed. Schools A and B were able to survey students across the entire ability range, whereas Schools C and D provided completed questionnaires only from students in the upper half of the ability range. The differences in the extent to which students from each school agree with each factor can, in part, be explained by this influence of ability grouping of the students as discussed below.

The most obvious differences between schools' agreement with the Purpose Factors are the low levels of agreement the students from School A have with *Personal relevance* and students from School D have with *Social relevance.* Agreement with *Personal relevance* as a purpose of learning science is strongly related to student interest levels and therefore could explain the results from School A, but does not offer an explanation for the School D result, which may stem from differing student experiences in lessons. During the lesson observations conducted as part of Stage 2 of this study there was a lack of explicit references to *Personal relevance*. This implies that there may be a link between the purposes presented by the teachers and what the students then understand the purposes to be. If this is the case it could be inferred that science lessons in School C have little or no explicit reference to *Social relevance.*

Topics can have a significant impact on student interest from the perspective of whether or not they see the material as having relevance to them, either personally or professionally. School A is in a rural area and as a result there are a number of students who are interested in farming. Knowledge of these socio-economic and wider situational factors could enable teachers to tailor lessons to link to topics which have a greater likelihood of triggering student interest, for example, farming is often a good trigger in School A, but may not be so effective in an inner-city school where students may have little experience of livestock. The challenge, however, is maintaining student interest once the content becomes more abstract and focused on the scientific explanation of a particular topic. At times students express the view that they would like to pursue a particular career as they have a strong interest in the field, however, they also state that their desire to work in a profession increases their interest in science lessons.

It is clear from the data presented that there is a strong positive relationship between the level of interest a student has and their recognition that they have a role to play in developing their interest. The lack of agreement that student effort can increase interest from students in School A, in contrast to the levels of agreement reported by the other schools, may go some way to explain the low levels of interest reported by School A students.

The responses from students in different ability groups

There is an increasing volume of research which suggests that there is an intimate relationship between interest in a particular area of study and attainment in that area (for examples, see Alexander, 2004; Chen and Darst, 2002; Renninger, 1992) as well as evidence for the link between prior knowledge of, and interest in, a specific domain (for review, see Tobias, 1994). The relative levels of interest, and agreement with the Interest and Purpose Factors, between students from different ability groups clearly reflect these relationships. It can be assumed that students in the lower ability sets (3 and 4) have not achieved as highly as their peers in previous assessments of their knowledge and understanding, thus they have lower prior knowledge and therefore lower interest levels. Following on from this, having lower interest can impact on their future attainment. The suggestion here is that the relationship between knowledge and interest is bi-directional and forms a positive feedback loop. This conclusion addresses the issue of cause and effect raised by previous studies (Chen and Darst, 2002). In addition, it also explains why the data from this study do not fit with the assumption held by the Model of Domain Learning; that Situational Interest declines as knowledge increases (Alexander, 2004).

Although gaining high grades in examinations will always be a major objective for students and their science teachers, I would argue that increasing student interest in science should also be an important aim for teachers and that students therefore need to be supported in being more learning-focused (learning for the sake of learning) and less ability-focused (demonstrating ability or trying to out-perform others). It is possible to influence the focus that students have with regards to their learning, and teachers who use more ability-focused techniques, which generally emphasise competition between students and the importance of grades, are likely to reduce the relationship between students being learning-focused and having a high self-concept of their ability in science, and thus reduce student motivation (Anderman and Young, 1994). Other studies (for example, Church, Elliot and Gable, 2001; Friedel *et al.*, 2007) have also found that students' achievement goals have an influence on their interest levels, with those who have mastery goals having greater interest in lectures or lessons.

The emphasis on ability-focused goals, when taken in conjunction with a lack of understanding of the links between performance on measures of ability and interest, could feasibly lead to a feedback loop that has a negative impact on students and actually decreases interest as they feel they are not making progress and gaining knowledge. Boggiano, Main and Katz (1988, p. 134) support this as they found that "children's self-reported perceptions of academic competence and personal control were found to relate positively to their intrinsic interest in schoolwork and preference for challenging school activities”. A key aspect here is the reference to ‘personal control’ as it was with the Interest Factors *Control* and *Personal endeavour* where the great difference lies between the students in each ability set; sets 1 and 2 agree with, and sets 3 and 4 are ambivalent about, these factors. For all other Interest Factors, all sets either agree with them or are ambivalent towards them, to varying degrees.

Self-determination theory states that if studying is entirely externally regulated, for example, to achieve a specific grade or qualification, it is likely that once this external benchmark has been achieved studying will cease (Niemiec and Ryan, 2009). However, the Purpose Factor *Professional relevance* is difficult to unpick as it refers to achieving a qualification and also includes ideas regarding the importance of learning material for a future career which can be argued to be the result of internal behavioural regulation (Niemiec and Ryan, 2009). As such, these two aspects within this factor may go some way to explaining the differences between responses from students in the different ability sets. Self-determination theory (Deci, 2015) states that if an individual repeatedly engages in an activity they are not interested in, it is possible that over time this activity may become self-determined, which, in turn, can lead to the development of interest in that activity. It can therefore be argued that students in the higher ability sets (sets 1 and 2) are quicker, or more able, to internalise the external motivation gained from having a strong agreement with the Purpose Factors, whereas those students in sets 3 and 4 who do not agree that there is a *Professional relevance* to their science studies therefore had little external motivation to internalise. As such, self-determination theory provides a plausible explanation for the low levels of interests and low levels of agreement with *Exploring science* reported by students in the lower ability sets.

The findings of the current study echo those of Anderman and Young (1994) as the students in the lowest ability group disagree with the Purpose Factor of *Personal relevance,* are ambivalent about the other Purpose Factors and have lower scores than students in other ability groups for all of the Interest Factors, which suggests that they place lower value on science than their peers. This lack of agreement with the Purpose Factors from the students in lower ability sets may also stem from students' lack of self-efficacy. As Wender (2004, p. 45) notes "subjective self-efficacy judgments are one of the most relevant determiners of success and persistence in a career". Therefore, it can be assumed that if students have low self-efficacy with regards to their science education they may, in turn, perceive little importance for science in their later lives.

Attendance, or absence from, lessons may also be a contributing factor to the differing interest levels reported by the students from the different ability groups. In general, in School A, students in the lower ability sets tend to have a lower level of school attendance. For the cohort of students who took part in this study the average attendance rates each ability class were, for the year students completed the questionnaire, as follows: set 1 = 97%, set 2 = 94%, set 3 = 91%, set 4 = 90% (where the lower the set number the higher the ability the students). This trend continued over the two years of the students' GCSE course with attendance rates being 95% and 88% for set 1 (most able) and set 4 (least able) respectively. This could influence their interest in, and view of the purpose of, learning science as it leads to a lack of consistency in learning and therefore less frequent opportunities for students to revisit and re-engage with the content. Furthermore, with relation to the Interest Factors, it reduces the consistency of who the students work with in small groups, therefore potentially making it harder for students to establish a strong peer group with whom they feel comfortable and are used to working. Alternatively, variation in attendance rates may reflect students' general lack of interest in school or increased interest in other activities as on average student attendance for this group decreased by 2% between Year 9 (13 to 14 years of age) and Year 11 (15 to 16 years of age).

Gender differences in student responses

The variation in the interest levels of male and female students is an unsurprising finding when considered in light of student voice research (for review, see Jenkins, 2006). However, this questionnaire did not distinguish between the different science domains (biology, chemistry, physics) or subjects (human organ systems, particle theory, forces) and therefore it could be expected that the common gender splits in domain interest may work towards equalising the scores. It is important to note that this result is not an artefact of female students naturally responding less positively to the questionnaire items as very little difference was seen between male and female students' responses to the *Purpose Factors* (see Figure 5.11) and female students were significantly more in agreement with three of the six *Interest Factors* (see Figure 5.10).

Gender differences in interest levels have been documented in most studies in the fields of science and mathematics education (for example, Jones, Howe and Rua, 2000) but not in other disciplines (for example, Chen and Darst, 2002). As discussed in Section 2.4 there are a number of theories as to why this gender gap exists including the stereotyping of 'scientists' or perceived socio-cultural pressures. An alternative explanation, which emerges on examination of the Interest Factor and Purpose Factor scores from the current study alongside the findings of other research, is that the mode of engagement with the content may have a significant effect on the direction of any gender difference in interest. For example, Ainley, Hillman and Hidi (2002) found that girls were more interested in all of the literary texts used in their research regardless of the content. This may explain why female students agree significantly more strongly with *Modelling* than the male students do. In contrast, there is no gender difference between strengths of agreement for *Puzzles* and male students agree more strongly with *Exploring science,* which focused on discussion of topics, than female students. Despite this difference, Kinchin (2004) found that the preference for learning in a constructivist rather than an objectivist learning environment was slightly stronger for girls, 93.3%, than it was for boys, 86.9%, although no other participant variables were measured or recorded.

Students' perceptions of their self-efficacy may also play a role in explaining the gender differences in interest levels. However, female students agree more strongly than male students with three of the six Interest Factors and with one of the Purpose Factors. Since female students seem to agree less with *Exploring science* than male students, although this is not a significant difference, it may be possible that the differences in perceived self-efficacy lie within the scientific domains rather than applying to learning in all subjects.

Contrary to many studies that have looked at students' attitudes to science and school science (e.g. Osborne and Collins, 2001; Sjøberg and Schreiner, 2010) the results of this research show very little in the way of gender differences in the students' responses. The pattern of responses for both the Interest Factors and the Purpose Factors is almost identical for boys and girls, with the only difference being girls agreeing more strongly with *Modelling* than *Puzzles* and boys agreeing more strongly with *Puzzles* than *Modelling*. Girls also agree significantly more strongly with the Interest Factors *Learning from others, Control* and *Personal endeavour* and the Purpose Factor *Professional relevance* than the boys. This may be an artefact of girls generally being more positive in their responses than boys (Osborne and Collins, 2001) or may in fact be a 'real' difference. As discussed above there seems to be a strong relationship between the strength of agreement with the Interest Factors and the level of agreement with the Purpose Factors.

The similarities between female and male students' agreement with the Purpose Factors appear to differ from previous findings, such as Osborne and Collins (2001) and Angell *et al.* (2004), which found that girls, more than boys, wanted to discuss ethical and controversial issues in their science lessons and wanted the topics to be relevant to their everyday lives. This would suggest that girls could have been expected to agree more strongly with both *Social relevance* and *Personal relevance* factors. However, the question asked here was not regarding their preference for learning but was what they felt the purpose of school science was. These results, when considered with the finding that girls agreed significantly more strongly with the *Personal endeavour* Interest Factor, imply that there is a mismatch between what female students feel would increase their interest in science and the messages they are receiving regarding the purpose of learning science. This may be due to the topics included in the curriculum or by the teaching style and delivery of these topics. Alternatively, the gender differences in agreement with the Purpose Factors may be the result of gender differences in response to the pressures and expectations placed upon, and held by, students with regards to the importance of gaining a good GCSE in science. It may be possible that female students, at age 14, are more aware about the importance of gaining qualifications for future careers than their male peers. However, despite a number of literature searches I have not been able to find any research which either supports or refutes this hypothesis. It may therefore be a potential area for further study but was outside the remit of the current project.

5.5 Comparison of the strength of students' and teachers' responses to the Interest Factors and the Purpose Factors

The Teacher Questionnaire administered in Stage 1 of the study was designed to allow comparison of the students' views along with what the teachers believed the students' view to be. This questionnaire was based upon Student Questionnaire 1: Sections 1 and 2 with the question stems modified to be:

> How interesting do **you think your students** find each of the following activities or opportunities? Please place a tick in only one of the boxes on each row to indicate how interesting your students do, or would, find each of the following' and 'To what extent do **you think that students may agree** with the following statements about the reasons why they learn science, particularly at Key Stage 4, in school?

The majority of the teachers worked in School A at the time of completing the questionnaire and therefore the mean scores for teachers are presented alongside those of School A students and all students in Figure 5.14, the strength of agreement with the Interest Factors, and Figure 5.15, the strength of agreement with the Purpose Factors.

As can be seen in Figure 5.14, the teachers believed that the students would agree that all of the Interest Factors would increase their interest level; in contrast the students only agreed with three of the six factors. Overall, the teachers mean scores are different from those of 'all' students; however, the only factor where this is a significant difference is *Exploring science.* Comparison of the scores of teachers and students from School A show a similar pattern, although School A teachers believe that students will score significantly higher for three of the six Interest Factors – *Personal endeavour, Modelling* and *Exploring science.*

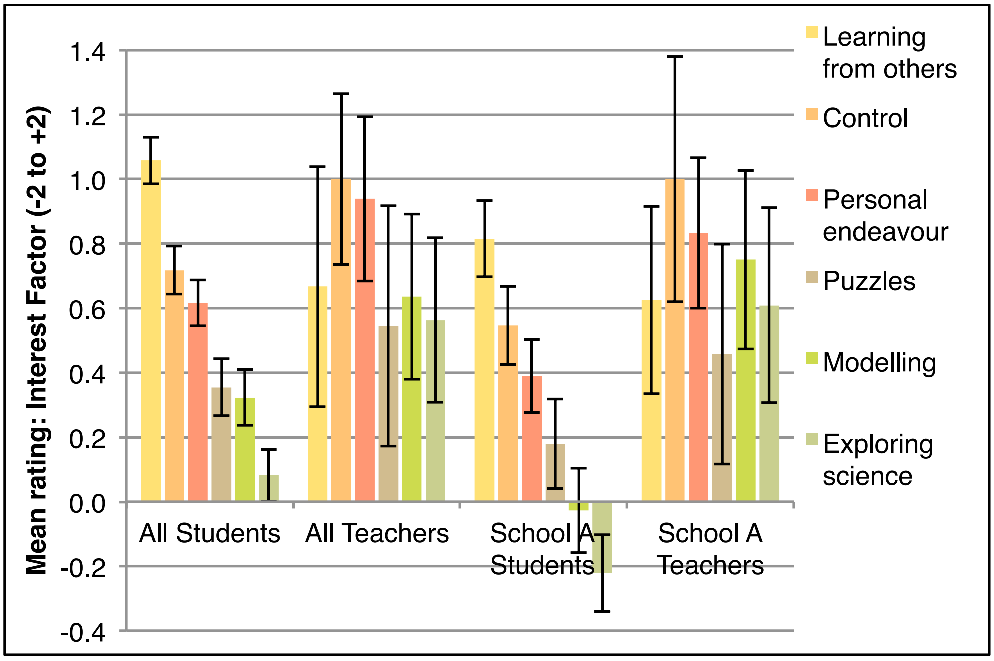


Figure 5.14 Mean strength of agreement with the Interest Factors from students and teachers (1.00 = agree, 0.00 = neutral, -1.00 = disagree).

Qualitative data regarding teachers' views were collected during Stage 2 of the research via lesson observations and focus group interviews. While this evidence showed that teachers were aware of the impact the Interest Factors had on student interest in lessons, the emphasis placed on each of the factors reflected the strength of agreement reported by the teachers rather than that reported by the students. As such, the importance and impact of *Personal endeavour* were raised by teachers a number of times throughout the study. During the focus group interviews and reflective discussions teachers reported that they aim to emphasise the ways in which the topics linked to previous learning or familiar contexts:

> During lessons I try to increase interest by relating the content to everyday life, for example, fuel cell powered buses which are now used in the local area. This is very important to this class. (26 Mar 2013, Mrs M Reflective discussion)

> We did concrete and I've got quite a few people who have got Dads who are in the building trade, so we made concrete and

> they were going /this isn't how you make concrete, this isn't-\ so that was great for getting their interest. (10 May 2013, Teacher Focus Group Interview)

This suggests that teachers believe that it is important that students are familiar with, or can contextualise, ideas being discussed. However, there are challenges when you have to develop one aspect of the students' knowledge and interest into a slightly different aspect of learning, as Mrs M went on to say:

> They were really interested in the concrete making but trying to move that on to the actual chemistry, nitty gritty that you are trying to teach is the harder bit. (10 May 2013, Teacher Focus Group Interview)

Teachers also showed awareness of a need to consider how the content is taught and how students are supported in understanding the content:

> Work must be presented in a way that the students can relate to. (21 Jun 2013, Teaching and Learning Group Discussion)

Teachers agreed that *Exploring* science would increase student interest significantly more strongly than the students did and this may be based upon their experience of students asking questions during lessons and wanting to discuss ideas in more depth.

> The most interesting ones are when I am wandering round and they start asking questions about the topics. You know, for example, we were doing combustion once and I had a picture of a rocket and I got so many questions about rockets and fast cars and motor bikes and things like that, that I think I spent about fifteen minutes just going round and the boys just asking questions about=Mr S ((chuckles)) Rockets and motorbikes.=Yeah and it wasn't all on task but I thought try and get their interest but the problem with that is that you have

> an objective to get to and you can't always do that by doing a free for all. (10 May 2013, Teacher Focus Group Interview)

> Curiosity questions posed to the students are a good way of opening up discussions and exploring ideas. (7 Jun 2013, Teaching and Learning Group Discussion)

> It is important to get the boys interested as this improves their behaviour for learning. The boys ask a lot of questions, but they are often 'self-centred' with this (they want to question and continue to discuss along a train of thought that they are interested in). This can lead the rest of the class to 'switch-off' if the discussion becomes one-to-one or focused with certain groups. (13 Dec 2012, Mrs M Reflective discussion)

In contrast to the differences between student and teacher responses for the Interest Factors, the teachers' responses regarding the Purpose Factors show the same pattern as that of all students, with *Professional relevance* and *Developing knowledge* being the two factors most strongly agreed with (see Figure 5.15). However, teachers also felt that students would not show a difference in level of agreement and would agree more strongly with these two factors. There are no significant differences with regards teacher and student responses for *Professional relevance, Personal relevance* and *Social relevance* as all groups are similarly ambivalent about these being purposes of studying science at GCSE level. However, teachers from School A believed that the students from their school would agree more strongly with *Developing knowledge* being a purpose of learning science than the students reported.

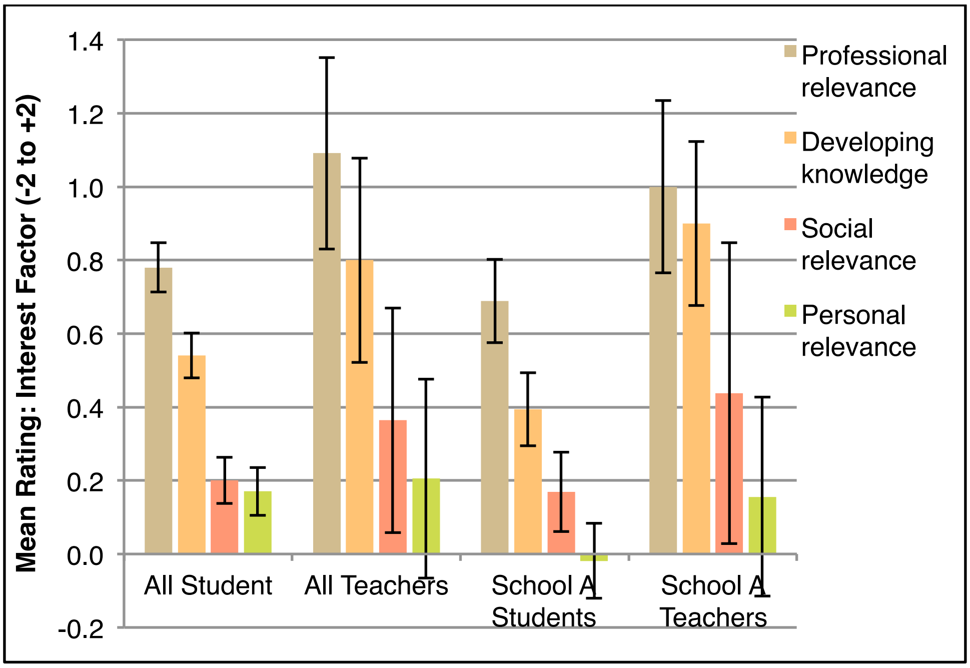


Figure 5.15 Mean strength of agreement with the Purpose Factors from students and teachers (1.00 = agree, 0.00 = neutral, -1.00 = disagree).

As mentioned above the majority of lessons observed explicitly communicated the purposes of *Professional relevance* and *Developing knowledge* only. This was also the case for lessons where either *Personal relevance* or *Social relevance* could have been emphasised, had the teacher broadened the scope of the lesson. At times the teacher even dismissed the role these different factors may have in learning, as demonstrated by the reflective discussion with Mr T following a lesson on the effects of alcohol:

> HD: What was the purpose of the lesson?
> Mr T: … b) to find out what they knew [about alcohol] and increase their biological knowledge rather than the socio-economic knowledge. (13 Dec 12, Reflective discussion)

The emphasis placed on *Developing knowledge* and *Professional relevance* appears to arise from teachers having a strong sense of these being the culture of schooling which has been embedded in a schools' ethos; it not just being a recent thing:

> Mr T: But isn't that how they're … trained now, to go from one GCSE to-. I know that when I was at school GCSE was the biggest thing in the world>you had to pass your GCSE< and then you passed your GCSE and it's like >no one cares about your GCSE< it's your *AS LEVELS* that you need to get, you have to get your AS and then it just goes on and on. As soon as you have done one exam it was the next set of exams and they were the biggest thing in the world. (10 May 13, Teacher Focus Group Interview)

> Mrs M: It's partly because we are so measured by exams [Mr S: Um=Mr T: Yeah] that's all we can focus on is exams and we forget that there is actually a life that they are going to that we need to develop them into. (10 May 13, Teacher Focus Group Interview)

The belief that *Professional relevance* is the key purpose for learning in science lessons was repeatedly emphasised to the students and embedded into everyday language and communication with students. The quotations which follow provide examples of how *Professional relevance* was referred to in lessons:

> Mr T: [The objective of the lesson is:] What are the long-term and short-term effects of drinking alcohol? Copy this into your books but leave a space so you could answer it at the end of the lesson as if it was a 6-mark question. (7 Dec 12, Lesson Observation, Class 1)

> What you need to know for GCSE-. (Mrs M, 4 Jul 13, Lesson Observation, Class 2)

> Student: Why do we need to know this as we don't make these things?

> Mrs M: Firstly the importance for career opportunities as there is a large chemical industry in the area and even if you do not work as a scientist it is important to be able to discuss this with customers etc. The second and more immediate answer is that in 12 months' time you will be sitting an exam and will be asked about this and the higher the grade you get the better the job you could get. (4 Jul 13, Lesson Observation, Class 2)

Although the vast majority of the references to Purpose Factors in lessons referred to *Professional relevance* and *Developing knowledge* the teachers involved in Stage 2 of this research were definite in their views of the importance of *Personal relevance,* as defined by this study, and by Van Aalsvoort (2004a), where the science students study ought to link to their everyday lives. However, this was often approached from the view of being a way to get students to learn and make progress through increasing interest, rather than viewing increasing interest as an aim in its own right.

> Mr S: I think it's relating it to stuff that interests them in real life, sort of stuff they haven't thought about and I think that biology lends itself to that really really nicely. Then they are really interested in it. And also talking about it from a personal perspective, if you can relate it to things that you've seen or done or experienced in life, erm, that makes it more interesting for them. (10 May 2013, Teacher Focus Group Interview)

Mr T also commented that the topics his students were most interested in were those with some sort of ethical issue behind them. When asked which topics his students, in the two highest ability sets, found the most interesting his response was:

> Genetically modified crops, organ donations [] and this was because they can have differing opinions and I can have a

> discussion and debate with them. (22 July 2013, Mr T Reflective discussion)

The teachers in the study believe that there is a link between a student's level of interest in the topics and how personally relevant they perceive it to be, as demonstrated by the quotation above, although the view that increasing interest did not always increase learning was also expressed:

> Mrs M: When it's related to them that's great. Sometimes that's great for getting their interest but it doesn't work well for the science you've got to teach. (10 Feb 13, Teacher Focus Group Interview)

Many of the teachers' comments above refer to specific activities or topics which enthused certain groups of students and the importance of considering how best to teach specific groups or classes of students was a recurring theme throughout the teacher focus group interviews and the teaching and learning group discussions. However, although it is probably true in all schools, it is concerning that pre-existing conceptions of different groups of students may bias teachers towards particular approaches with certain groups. For example, although the quotation below was made during a discussion of a particular class it suggests that, some teachers may hold strong gender stereotypes:

> They [the boys] want to relate ideas to real-life and their personal experiences. One way to get the girls more interested and on task is to allow them to produce 'something which looks pretty' or lots of information, such as notes. All of the students like different things but they all like practical work; however, this may be because some of them may consider it an easy option. (26 Mar 2013, Mrs M Reflective discussion)

Teachers may also hold negative stereotypes of students in lower ability sets:

> . . . and you are asking Year 9 there and if you think about the attitude to learning of sets 3 and 4. (10 May 13, Teacher Focus Group Interview)

This quotation was taken from a discussion with regards a specific class, whilst studying a specific topic, however, the implication behind it was that the students in sets 3 and 4 do not really care about learning and progress.

5.6 Discussion: The similarities and differences between teacher and student responses

Teachers agree more strongly than the students with the majority of the Interest Factors and, whereas students were ambivalent about all but two of the Interest Factors, the mean teachers scores demonstrate that they agree that all of the factors would increase student interest in learning science. However, teachers had a lower level of agreement than students with *Learning from others.*

As science teachers have chosen a career path which allows them to 'explore' science, it might be expected that that *Exploring science* has the largest difference between students' and teachers' mean level of agreement with any of the Interest Factors (teacher score = 0.563, student score = 0.082). In contrast the difference in scores for *Modelling* (teacher score = 0.636, student score = 0.323), which is particularly marked for teachers and students from School A (School A teacher score = 0.750, School A student score = -0.027) was unexpected. This difference may be explained if teachers and students have differing understandings of what models are. For example, Van Driel and Verloop (2002) found that experienced teachers integrate aspects of both logical positivism and social constructivism in their understanding of the nature of models, while

Grosslight *et al.* (1991, p. 800) concluded that students tend to hold a "naïve realist epistemology" and tend to think of models only as physical copies of reality, though with some students understanding that models play a role in helping to communicate ideas. Furthermore, if there is no consensus between teachers, for example, (Van Driel and Verloop, 2002, p. 1150) found "large variation in the criteria the teachers used to determine whether or not specific examples qualified as scientific models", students will receive inconsistent messages with regards to the nature and purpose of models in science as they progress through school.

In general, the students' strength of agreement with each Purpose Factor follows the same pattern as that of the teachers. It is, however, difficult to assess from the data collected whether or not there is a direct, or even a causal, link here which results in the students adopting and internalising the messages regarding purpose that the teachers communicate to them. An alternative explanation may be that both groups are internalising and reproducing the messages from wider fields including Ofsted and the government Department of Education. It may therefore be pertinent for teachers and the wider education community to consider the broad messages they are sending to students with regards to learning in schools.

Although the pattern of responses to the Purpose Factors is the same, the mean teacher score is higher than the mean student score for each of the factors. Similar patterns have been found in other research. For example, in 2004 it was found that although 64% of science teachers sampled felt that the science topics taught in more than half of their science lessons were relevant to students' lives only 35% of the students agreed (Ruddock *et al.*, 2004).

There are a number of possible reasons for the differences between the teachers' and students' responses for both Purpose and Interest Factors. It could be argued that students and teachers have interpreted statements differently and based their responses on different levels of evidence. This could be used to explain the strikingly significant difference between the strength of agreement with *Exploring Science*. Whereas students overall were ambivalent or slightly positive, students from School A disagreed with it but teachers from School A agreed that *Exploring Science* interests students. Students may base their scoring of this statement on their initial response regarding how they feel generally about science lessons or in comparison to the other activities listed. Teachers, on the other hand, may have considered student behaviour in lessons more widely and thought about the frequency with which students ask questions in lessons.

One possible explanation for differences between teacher and student responses is that these may be an artefact of the survey methodology. Teachers may have misread the question and answered from their own, personal point of view. Alternatively, they may have answered with a specific student in mind rather than considering the 'average' student. It would be natural for the teacher to have considered a student with whom they find it easier to identify and, as such, that student would be most likely to be interested in science and see the value of studying the subject up to the age of 16. It can be assumed that science teachers have an interest in learning science and achieved highly in science at school, since an Honours Degree in a scientific area is a requirement for completing a secondary school (11-18 year olds) teaching qualification. They are therefore more similar as a group to the students in ability set 1 (the highest ability set). This argument is supported through comparison of the teachers' responses to the students' in ability set 1 where the only differences between their levels of agreement with the Interest Factors are that students agree more strongly with *Learning from others* and teachers agree slightly more strongly with *Exploring Science.* In addition, there are no significant differences between the teachers' responses and those of students in ability set 1 for any of the Purpose Factors. Furthermore, students in ability set 4 agree significantly less strongly with all but one of the Interest Factors and Purpose Factors. If teachers were responding to the questionnaire based on an understanding of the views of the 'average' student in the school it could be expected that their responses would be closer to students in ability sets 2 or 3. If the above explanation; that teachers naturally identify most easily with students in set 1, is reflected in everyday practice it may go some way to explaining the different interest levels for students in different ability sets:

> Given the difficulties adults can have in adjusting to the child's way of looking at things, it may not be too provocative to suggest that peers are for some things a better context for intersubjectivity – they can often understand each other more directly. Peer relations may in other words be a good inter-psychological context to further intra- psychological functioning. (Blatchford *et al.*, 2003, p. 7)

Teachers voiced the importance of contextualising the content for the students a number of times during the focus group interviews and discussed instances where they had given students real-world examples to support their learning of new content. Students, on the other hand, rarely commented on this facet of teaching with regards to it increasing their interest. This suggests either that students do not perceive a clear distinction between theoretical and applied content or that they do not feel that covering the content in a particular context has a role to play in affecting their interest level. Appleton and Lawrenz (2011) have reported that often students hold different views from the views of their teachers about what is considered to be 'practical' or 'real world' in the context of mathematics lessons. If this discrepancy was also present in science lessons it may further explain the differing levels of comments about context from the teachers and students in the current study.

As discussed above, it is clear that different groups of students have very different profiles with regards to their interest in learning science and the factors they believe will increase this interest. It is also clear that students have a range of views regarding the purpose of learning science and the strength of agreement with the Purpose Factors may arise, at least in part, from the dominant messages which students receive from their teachers. From the analysis of the differences in strength of agreement with the *Interest Factors* between the different schools, genders and ability based on 'setting', it is clear that there is a direct link between a student's level of agreement with the factor *Exploring Science* and their expressed interest in science and science lessons. This link supports the validity of the data collected here and implies that developing a student's affective and cognitive responses to science topics is key in increasing their interest in science lessons. Given the role that teachers play and the level of influence they have over students it is logical to consider the possibility of increasing student interest in learning science through targeted work with subject teachers. It is this goal which is considered in Chapter 6, together with the results of working closely with two classes of students and two other teachers throughout Stage 2 of this research. School A was chosen for Stage 2 of the research, initially, for logistical reasons. However, this decision was strengthened as the data analysis from Stage 1 of the research highlighted the clear differences between the attitudes and beliefs of students from School A and students from the other three schools. Students from School A had significantly lower levels of Situational Interest than those in Schools B, C and D. This difference was seen despite the School A students having the same ability range as the students from School B (ability sets 1-4) and a similar ratio of female to male students to all of the other schools. School A students also reported lower Individual Interest than students in Schools C and D, but this may be explained by the students from Schools C and D only representing the top two ability sets from these schools. The variation between School A students and the other students continued with regards to their levels of agreement with the Interest Factors, the Purpose Factors and the role which students have to play in developing their own interest. Given the extent and direction of these differences, the design of Stage 2 of the research was developed to explore some of these issues in a more qualitative way with a view to seeing whether or not it was possible to increase the levels of interest reported by some of the students from School A.

Chapter 6: Supporting the development of interest

As described in Section 3.3 an advantage of completing this work part time, in the school I work in, was the opportunity to work with the same groups of students and teachers over the two years of the student cohort's GCSE studies. In particular, it provided the teacher participants and me the opportunity to reflect on existing research, the findings from Student Questionnaire 1 and the focus group discussions to develop our own teaching practice in order to support the development of student interest. This chapter reports on the approach, analysis and impact of the actions taken, as a result of this reflection, in the overall context of the current study. Data tables, where appropriate, for figures in Chapter 6 can be found in Appendix 10.

As reported in Section 5.1, the Situational Interest levels of students in School A are significantly lower than those of the students in the other three schools surveyed. This suggests that these students are less interested in science lessons than the general cohort of students across the region. Anecdotal reports, from teachers and parents, indicate that the students in School A are excited by science when they start at age 11 but that a significant number of students have lost interest by the end of Year 9 (age 14). The evidence presented in Section 5.1 certainly demonstrates the wide range of interest levels of students across all schools at age 14. There is no specific evidence as to when a decline in students' interest in science occurs for the students at School A. The reported declines, both from academic studies and anecdotal evidence, in student interest in science were particularly pertinent within the context of this study as the starting interest levels of students in School A, as measured by Student Questionnaire 1, were significantly lower than those of students in other schools (see Section 5.1). Furthermore, School A students were the only cohort to have lower Situational Interest than Individual Interest. This implies either that these students had lower levels of Situational Interest when they started Secondary School or, which is more likely given the established levels of Individual Interest, that one or more aspects of the culture of School A are leading, in some way, to decreasing student interest in science lessons. This is obviously a concerning issue and may be a result of curriculum design, pedagogical techniques or wider issues which are outside the teachers' direct control.

Towards the start of Stage 2 of the method (see Figure 3.1), I shared the findings from Student Questionnaire 1 with the teacher participants during the first Teacher focus group interview (9 Nov 2012). All of the teacher participants were particularly interested in the stark differences between the students from School A and the students from the other schools. The issues of why these students had such low levels of interest and whether or not they could be increased formed part of the discussion that followed.

Although there was the opportunity to observe four different classes (1, 1b, 2 and 4), it was agreed that we would focus on two specific classes of students (Class 1 and Class 2) as these classes were taught by two of the teachers involved (me and one other) and the other classes were only taught by one participating teacher. Each of the teacher participants agreed to take part in a reflective discussion with me following each of the observed lessons, to agree strategies which could be employed to try to increase the interest of the students in those classes. During the second Teacher focus group interview (10 May 2012) Mrs M proposed that we meet more frequently to allow more time for reflection on strategies and discussion of the research; those attending these meetings were referred to as members of the Teaching and Learning Group.

6.1 Profiling groups of students

One of the issues raised during the Teaching and Learning Group discussions was that of being able to gain a deep understanding of the students which can then be employed to develop their interest. As is clearly demonstrated in Chapter 5, there is variation between different groups of students and it is important to consider the particular profiles of each class of students. It was therefore decided that, since we had of data available, from Student Questionnaire 1, we should take advantage of the opportunity and focus our attentions on two classes (Class 1 and Class 2) as they completed their years studying GSCE Science and Additional Science or Biology. Both of these classes were taught by one of the teacher participants and me and were timetabled in such a way that provided me the opportunity to observe the teacher participant's lessons without the need for missing any of my own classes. Class 1 (14 girls and 15 boys) all elected to study separate science GCSEs, i.e. to take three GCSE qualifications, one in each of biology, chemistry and physics. They were considered to be some of the highest ability students within the school having target grades between A* and B. The majority of students in Class 2 (13 girls and 14 boys), considered to be middle ability students, had a target grade of a C with the remaining few having a minimum target of a C. This class completed two separate GCSE qualifications; the content for Science GCSE was taught in the first year of study and the content for Additional Science GCSE was taught in the second year. Further information regarding the students in these classes can be found in Section 3.3.

The majority of the students provided personal information on the Student Questionnaire 1, which they completed during the 2011 summer term of their Year 9 studies. This information, which included their science class and gender, was used to create class-specific profiles with regards to their levels of agreement with the Interest Factors and Purpose Factors (see Figures 6.1 and 6.2

below). The information has been presented in a manner to allow the responses from each class to be compared to all of the answers given by all the other students in the study and the other Year 9 students from the same school. These data informed, in part, the teaching strategies employed by the teacher participants, with Classes 1 and 2, in an effort to increase students' interest in learning science.

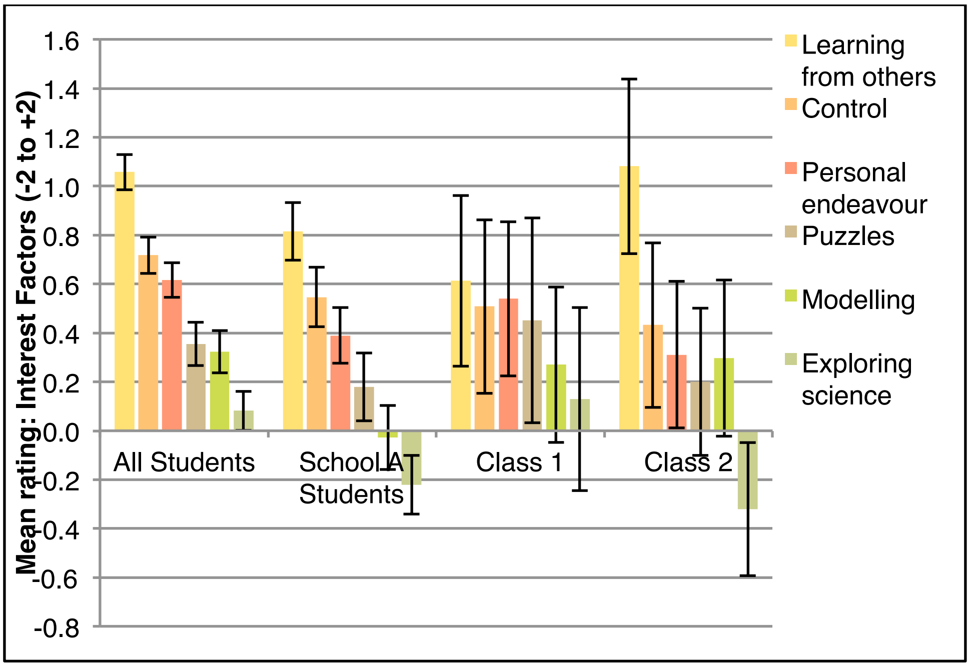


Figure 6.1 Mean scores, and 95% confidence limits, for the strength of agreement with the Interest Factors from Class 1 and Class 2 students, in comparison to other students (1.00 = agree, 0.00 = neutral, -1.00 = disagree).

As can be seen from Figure 6.1, members of Classes 1 and 2, unlike all students, have few significant differences between the Interest Factors. The exceptions to this are found in the profile of responses from the students in Class 2; the strength of agreement with *Exploring Science* is significantly lower than all factors apart from *Puzzles* and the agreement with *Learning from others* is significantly higher than all factors apart from *Control*.

When comparing the pattern of agreement with the Interest Factors, it is interesting to note that Class 1 has a similar pattern of response to that of the teachers who completed the Teacher Questionnaire, also in June 2011 (see Section 5.6 for a discussion of the reasons for these similarities).

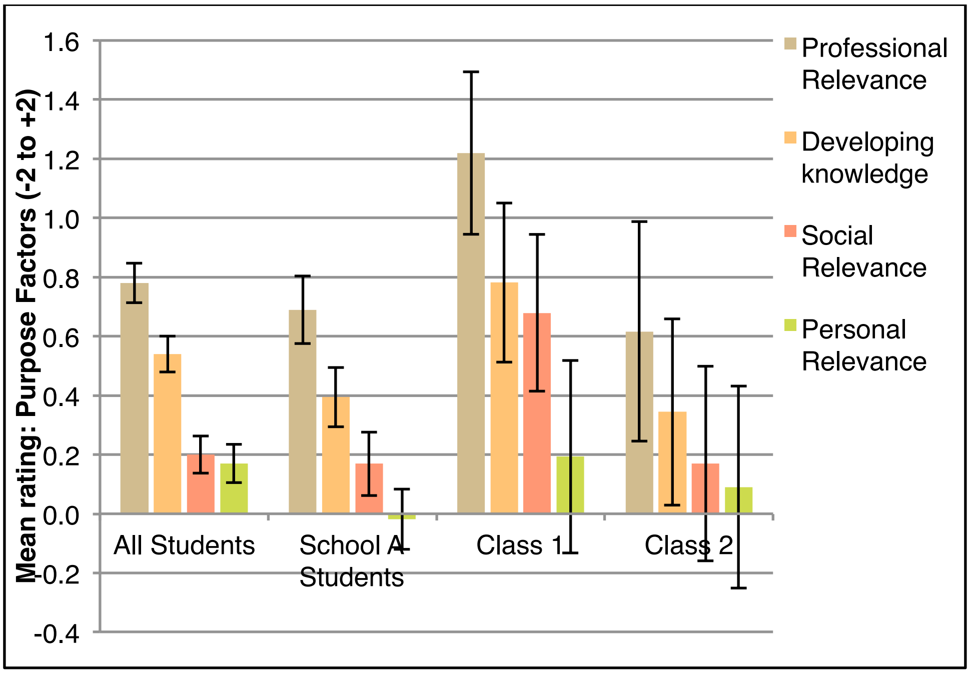


Figure 6.2 Mean scores, and 95% confidence limits, for the strength of agreement with the Purpose Factors from Class 1 and Class 2 students, in comparison to other students (1.00 = agree, 0.00 = neutral, -1.00 = disagree).

The relative levels of agreement with the Purpose Factors highlight, yet again, the importance of understanding the profile of a specific group of students (see Figure 6.2). Class 1 students agree significantly more strongly than all students and School A students with *Professional relevance* and *Social relevance.* In addition the students in Class 1 agreed significantly more with *Developing knowledge*, than their peers in School A. There is no difference between the level of agreement with *Personal relevance* between the different groups. Class 2 students have the same level of agreement with the Purpose Factors, on average, with the other students in School A, which is to be expected as these students were in either ability set 2 or 3 when they completed the questionnaire (see Section 5.2 for comparison of data by ability set).

In a normal classroom situation, it is rarely possible to profile a group of students to the extent allowed by the questionnaire and quantitative data analysis carried out here. However, it is possible to build a reasonably comprehensive understanding of how to engender interest in the learning of science, by talking to individual students, experimenting with a variety of teaching and learning activities, and reflecting on the discourse which takes place within a lesson. In many ways, the understanding gleaned from these more inter-personal methods of collecting data is richer and provides a stronger foundation for building relationships with students. As Mrs M stated:

> [Class 2] is very diverse; some students are weak or a 'set 2', others can't get it together in exams (struggle with retention and communication of information) but are interested in lessons. There are a few groups which can be chatty or disruptive but really value (and need) one-to-one support and knowledge of them. If this individual attention is given then they are more engaged. A couple of the students do the work but do not really engage with it. I taught the majority of this class when they were in Year 8 [12-13 years of age] and so know them very well and did not have to train them at the start of the year in the same way you have to with other classes. The key to getting students interested in lessons is knowing the pupils and knowing how you teach which allows you to tailor lessons to the pupils and yourself. There is no point trying to teach in a way that you are not comfortable. (26 Mar 2013, Miss M Reflective discussion)

I would agree with the comments about the diversity of the group and came to the same conclusions with regards ability and progress whilst I was teaching them. I also found that they really valued individual attention but needed this attention to be provided in a wide variety of ways. One of the ways in which these students received more individual attention was through involvement in this research;

discussing their interest, and influences on it, during lessons or focus group interviews.

6.2 Classroom strategies for supporting the development of interest

Mrs M, Mr T and I put in place some small, manageable interventions which were developed as a result of increased awareness of the factors involved in student interest. Where these interventions were part of a larger focus they are included in Figure 3.4 as a 'teaching and learning focus'. In addition to these specific interventions the teacher participants and I worked to support the development of student interest based on our understanding of the research literature and the results of Student Questionnaire 1 and the Teacher Questionnaire, which were discussed in the Teaching and Learning Group meetings. A description of the range teaching strategies used can be found in Table 3.10. In addition, a more detailed description of some of the strategies is provided here to exemplify how strategies were enacted in the classroom.

Practical work is a key component of science lessons and is widely considered to increase students' levels of interest in science lessons (Abrahams, 2009; Toplis, 2012). However, the statement regarding practical work from Student Questionnaire 1: Section 1 was not a component of any of the Interest Factors generated. It was agreed that we already carried out a large amount of practical work and that doing it in itself was not likely to impact on student interest levels. As such, rather than adjusting teaching to 'do more practical work', it was decided that we would instead consider how the Interest Factors could be incorporated into lessons through practical activities (see pp. 264-271 for further discussion).

The first 'teaching and learning focus' period, from 10 Jun 2013 to 22 Jul 2013, looked specifically at how we could incorporate *Personal* *endeavour* into the lessons. This was considered an important area of focus as students in Class 1 agreed that it increased their interest, but students in Class 2 were more ambivalent about it than the rest of the students from School A or other schools who, on average, agreed that *Personal endeavour* increased student interest. It was agreed that there might be a positive impact if we could increase the awareness the students in Class 2 had of *Personal endeavour.* To support the teacher participants in implementing this focus, following our discussion, I shared the component statements (from Student Questionnaire 1: Section 2) for *Personal endeavour* together with a list of suggested question stems which teachers could adapt for their lessons.

One very simple activity that incorporated aspects of *Personal endeavour* and *Exploring science* is a three statement plenary where students were asked, at the end of the lesson, to complete the following three sentences with regards the content of the lesson:

- I already knew . . .
- I now know . . .
- I would like to know . . .

This was then extended to include *Social* or *Personal relevance* by asking students to complete a fourth sentence relating to the lesson content:

- Knowing [a relevant aspect of the lesson] is important for . . .

This short, and relatively simple, activity was used with both classes throughout, and beyond, the 'teaching and learning focus' period. At various intervals students were asked to look back and reflect on whether or not they now knew what they had previously written they 'would like to know'. This was either done individually or as a group activity to incorporate aspects of *Learning from others.* An alternative plenary which was introduced was to ask students to hold up the number of fingers on one hand which represented their confidence with specific aspects of the lesson, where no fingers meant they believed they did not know anything and five fingers represented a high level of confidence. This quick activity required students to consider their own feelings as well as allowing them to communicate these in a subtle manner. Often students who were lacking confidence would hold their hands close to their bodies so only the teacher could see. An advantage of both of these activities is that neither required the preparation of additional resources.

Another activity which was used with a view to increasing awareness of *Personal endeavour* can be seen in Box B. This activity was started during the summer term in the lesson before the students completed two weeks of work experience away from school. The students were allowed to work individually or in pairs of their choosing to allow them the opportunity for *Learning from others*. The topics listed, with the exception of 'the endosymbiotic theory of cell evolution', had all been covered during the previous

Box B: Activity focusing on *Personal endeavour*

Class 2 Extension and Application

Task: Produce an informative poster on one of the following topics.

- Cells from different Kingdoms
- Prokaryote cells
- The endosymbiotic theory of cell evolution
- DNA and its discovery
- DNA: Structure and function
- Free choice – something related to the topics covered so far

Content: Your poster should contain each of the following elements (each is worth 5 marks)

- Background information on the cells/theory/molecule
- Information on why it is important to science and society
- A personal reflection on why you find this interesting
- At least one scientific diagram
- At least one other relevant image

Assessment: You will be marked on the following aspects of your poster

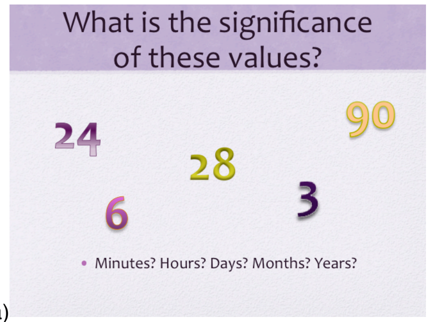
The content presented	/25
Use of scientific terminology	/5
Overall layout and presentation, including a logical flow	/5
Total	**/35**

sequence of lessons. When the students returned from work experience they had two days of school left and biology lessons on each of those days. Rather than watch a video or do a quiz, which are common activities for lessons at the end of the school year, I chose to continue with this activity so the students could complete the task (22 Jul 2013, Self-observation). I was impressed at how hard the students worked on completing the task without distraction, despite being on computers, and only one pair of students had to be reminded that they should not be playing computer games. All groups managed to reflect on why the topic they chose was interesting and important and students said that this aspect of the work had been particularly engaging.

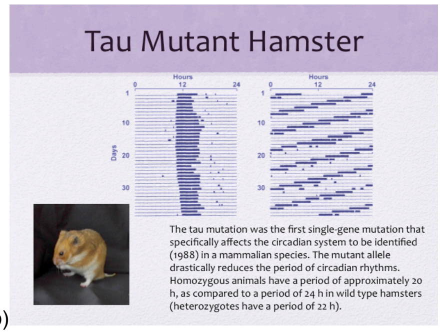
The second 'teaching and learning focus' was on supporting a number of the Interest and Purpose Factors in conjunction with the preparation and completion of the 'Controlled Assessment Task' (CAT), the internally assessed component of the GCSE Additional Science and the GCSE Biology courses. Specifically, these lessons (between 1 Nov 2013 and 16 Feb 2014) had an emphasis on *Learning from others, Exploring science, Developing knowledge* and *Professional relevance.* As part of the preparation for this assessment students completed a similar practical investigation where, in groups, they could formulate their own hypothesis, under some guidance. Specifically, for Class 1, this involved investigating a factor which affects the rate of enzyme-controlled reactions. Although they had already studied enzyme theory this provided students with the opportunity of *Exploring science*, whilst *Learning from others*. *Learning from others* was also emphasised through the use of peer support to improve the first draft of the investigation write-up. After the first draft had been assessed, students were grouped based upon the specific areas of the write-up they needed to improve (6 Jan 2014, Self-observation). For example, one group was asked to focus on incorporating enzyme theory into the explanations of their conclusions and evaluations, whereas another group needed to improve the justification of their plan and the evaluation of their conclusions. These groups were purposely different from the groups that had completed the investigations too, requiring students to work with others and focus on the underlying principles for improving their work. The relevant aspects of *Developing knowledge* (using equipment, carrying out investigations, interpreting data) and *Professional relevance* (the contribution the CAT makes to the overall grade) were also emphasised throughout this preparation work. A similar sequence of events and emphasis on the Interest and Purpose Factors was used with both Class 1 and Class 2 for their Chemistry CATs, although the underlying topic for the investigation differed (for example, 12 Dec 2013, Lesson Observation, Class 2).

The students in Class 1 reported a similar level of agreement with all of the Interest Factors and agreed with three of the Purpose Factors. The lowest levels of agreement were reported for *Exploring science* and *Personal relevance,* although these were still higher than the rest of the School A students, possibly as a result of these students having chosen to study the three separate science GCSEs. It was therefore decided that Mr T and I would use a wide range of teaching strategies to incorporate all of the Interest and Purpose Factors, although there was slightly greater focus on increasing opportunities for *Exploring science* through the use of *Puzzles*. An example of how this was implemented is shown in Box C (24 Feb 2014, Self-observation). Slide a) was used as a starter activity for the whole topic and slide b) was included to provide some in-depth scientific research above and beyond the requirements of the examination specification.

Box C: Presentation Slides from a lesson on Biological Rhythms



a)



b)

Both of these slides prompted discussion between students and led to them asking the teacher a number of curiosity questions to further develop their knowledge.

The students in Class 2 had a more unusual pattern of responses to the Interest Factors, agreeing with *Learning from others* but being ambivalent about the rest of the factors. In comparison to the rest of the students at School A these students agreed more strongly that *Modelling* would increase their interest in learning science and therefore this became one of the key strategies used in lessons. Activities used included role-playing the movement of particles where relevant, e.g. diffusion, osmosis, rate of reactions, enzymes. We also built models of DNA out of jelly babies and strawberry laces (19 Jun 2013, Self-observation). The other key strategies used with this class were *Learning from others* and *Control* which included allowing students to present information or complete revision in ways of their own choosing. Furthermore, these students were encouraged to work in small groups to discuss ideas with each other (for example, 12 Dec 2013, Lesson Observation of Class 2). On a number of occasions the group work was more structured with students being given different roles (for example, Team leader, Recorder, Reporter, Timekeeper). During a lesson on the effects of smoking (15 Feb 2013, Self-observation) these factors were brought together as for the second half of the lesson students were assigned roles within their groups and had to produce some information on the effects of the different components of cigarette smoke on the body. They were invited to use any source of information they wanted to: their notes; textbooks; information / advice leaflets provided; the internet (although there was only one computer), and could present the information in any way they wished. Most groups chose to produce annotated posters but one group wrote ‘Facebook’ profiles for each of tar, nicotine and carbon monoxide.

It was particularly noteworthy that all of the students in the study were ambivalent about *Social relevance* and *Personal relevance* being reasons for studying science at this level. In an attempt to increase awareness of the *Social relevance* aspects of science I displayed pictures of famous scientists which included descriptions of some of their key contributions to science next to the door of my laboratory where students would see them as they waited outside of the room. Since this display was produced a number of students have asked me about the people included. I decided to see if *Personal relevance* could also be increased through the use of a display and so introduced a ‘Favourite Words’ wall where students of all abilities have suggested scientific / biological terms they like, from ‘test tube’ to ‘bifidobateria’. The students have taken ownership of this wall and as they have come across new terminology a number of students have suggested these terms be added to the wall.

It was also clear, from the data collected during Stage 2 of the research, that the arrangement of, and seating plan for, the students in the classrooms influenced student interest and peer interactions regardless on the nature of the task set. Since the majority of science classrooms, in this study and across the country, group students around large tables, students are more likely to engage in discussions by the fact that they are facing each other. In fact, throughout the observations conducted here it was extremely rare to see students working entirely independently on a task; teachers rarely asked students to work in silence and students never did this voluntarily.

6.3 Findings: Impact on student interest levels

At the end of Stage 2 of the study the students in Classes 1 and 2 were invited to complete Student Questionnaire 2, which was a repeat of Student Questionnaire 1: Sections 3 and 4. The results of this, along with students' behaviours during the observed lessons and responses during the student focus group interviews, were scrutinised for evidence of any changes in the students' interest levels. This evidence, together with any evidence of impact on teachers due to engagement with this research, is discussed here.

The quantitative data collected from students in Classes 1 and 2 showed that there was no significant impact on the students' Situational Interest, nor on their levels of Individual Interest, as a result of the trialled interventions. However, there was, on average, an increase in the students' interest scores for students in both classes (see Figure 6.4). Not only did the Situational Interest scores increase, on average, by 3.1 for Class 1 students and 4.5 for Class 2 students, the Individual Interest Scores also increased (Class 1 by 3.2; Class 2 by 2.2). However, due to the small sample sizes it cannot be concluded that these increases are statistically significant. An indicator of developing Individual Interest is an individual's desire to re-engage with the content. Therefore, based upon the number of students intending to go on to study science further, it may be argued that more students were starting to develop Individual Interest by the end of their GCSE courses (see Table 6.1).

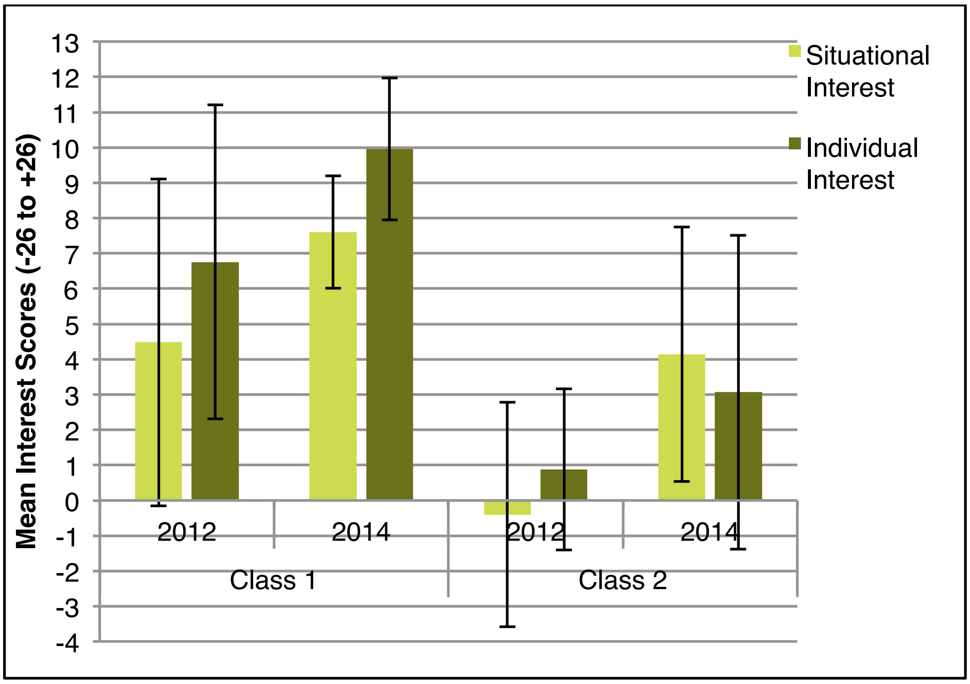


Figure 6.3 Mean interest scores (with 95% confidence limits) for students in Class 1 and Class 2 as measured by Student Questionnaire 1 (June 2012) and Student Questionnaire 2 (May 2014) (potential range of scores is from -26 [very low interest] to 26 [very high interest]).

Table 6.1 Percentage of students intending to go onto further study of Science or STEM subjects

Subject	**Percentage of students who say they are intending to complete further study in each subject area (%)**			
	Class 1		**Class 2**	
	2012	**2014**	**2012**	**2014**
Science subjects	67	81	20	29
STEM subjects (inc. Science)	72	96	36	58

The students had clear views about how the start of the course had influenced their subsequent interest in the different science subjects. For those interviewed a ‘good’ start was particularly important, as illustrated by the quotation below, as students believed that consistent and maintained teaching at the beginning of their GCSE study (Year 10) influenced their interest in each domain for the rest of the two years.

> HD: How has your interest in the Science subjects changed over the last two years?

S1: In some aspects I prefer like biology and chemistry because I understand it more whereas I don't really like physics because at the beginning of the year, Year 10, we didn't have a teacher so we didn't like, kind of, sit down and start work straight away so I think it was like if we had settled down right at the start.
S2: The interest was kind of gone within 2 weeks of Year 10.
(1 May 2014, Student Focus Group Interview)

The implication here is that without the clear expectation that they would face cognitive and affective challenge, or be required to meet specific targets and produce work, they did not engage with physics and did not have any interest in it, however, none of the students expressed the view that physics had no potential to be interesting.

All of the strategies described in Section 6.2 and in Table 3.10 resulted in the majority of students either being more engaged in the tasks they were required to complete or in them asking curiosity questions, or both. These simple changes appeared to be extremely successful in increasing student interest and autonomy. For example, Mrs M reported that she was trying to do some revision with Class 2 and the students were not listening to her but instead distracted by other things, i.e. having their own conversations, doodling. After a few minutes, she modified the lesson plan and asked to the students to get on with revision in any way they wanted to (she suggested some effective strategies). Almost instantly the students changed their attitude towards the lesson and settled to complete tasks (9 May 2014, Teaching and Learning Group Discussion).

Mr T also found that giving more autonomy and control over their work increased the interest levels of the students in Class 1. During our first reflective discussion, he said that he did not think that the students were very interested in the lesson on alcohol as they already knew something about the topic and wanted to ask their own questions. His response, when asked how he felt he could increase their interest in future lessons, was:

> In a previous lesson, I used smoking leaflets to answer questions. They could do research on computers. This would increase interest as they will find out more information on the way to answering questions, e.g. what is cancer? It would also provide an extension of knowledge. (13 Dec 2012, Mr T Reflective discussion)

During this reflection, Mr T considered the activity which may have resulted in higher student interest levels in a previous lesson compared to the lesson we were discussing and use this insight to plan future lessons.

The teachers involved in this research became more aware of student interest levels and how they changed over time through their own observations of student behaviours. For example, Mr T felt that over the first year of study the interest of students in Class 1 waivered as a result of the differing levels of challenge presented by the different topics. He believed that when they found something easy they were less interested and when faced with the more challenging topics they 'make it more complicated than they need to' (22 Jul 2013, Mr T Reflective discussion); however, they appeared to find these more challenging topics, such as mutations and genetic modification, more interesting.

In addition to student interest levels increasing there were marked changes in students' general behaviour, both in and out of lessons:

> At the end of the lessons all students were smiling and most said "goodbye", "thank you" or something similar as they left the room – this is a stark contrast to the start of the year when they would leave in silence, or involved in their own

> conversations. This indicates that the students are more involved in the lesson and that we have formed positive working relationships with these students. (27 June 2013, Self-observation, Class 2)

Furthermore, students became more willing to discuss their science lessons as informal chats in the corridor during break- or lunch-times (see Section 4.2, p. 143, for an example of this).

As part of the teaching and learning focus on *Personal endeavour* students in Class 2 were given the task of completing a poster (see Box B). Part of this activity asked them to reflect on why they found this topic interesting and why they felt it was important for science and society. All groups were able to reflect on these points and often the statements were linked with regards the underlying idea, for example:

> IMPORTANT: [Classification] is important to scientists as it allows them to accurately identify individual species wherever they are.
> INTERESTING: [Classification] is a significant part of biology and all organisms are classified using this system. It is used to identify certain types of species which gives an insight of how many types of species there are on the planet.

Other pairs of statements were more diverse such as this one, which draws on *Social relevance* as a source of interest:

> IMPORTANT: Watson and Crick had no idea that what they had discovered would change the world forever.
> INTERESTING: DNA is so interesting because the people who discovered it were just normal people who worked hard for their work and it paid off and they will be remembered forever.

For a number of students, the interest aspect was directly related to their knowledge, either having or needing it:

> IMPORTANT: [DNA is needed for] Disease diagnosis and treatment, paternity and legal impact, forensics and agriculture.
> INTERESTING: [DNA is] Related to our bodies which we find useful and it is easy to understand.

and:

> IMPORTANT: Knowing the exact sequence of DNA we can prevent diseases.
> INTERESTING: It is important to know about it for the exam next year.

Adding this simple requirement to the task provided a level of insight into the students' attitudes and beliefs about the topics that would otherwise have been missed. In a similar way to the 'three sentence plenary' it not only requires the students to reflect upon their own learning and areas of interest but also gives the teacher a greater understanding of the students.

The students were asked both in June 2012 (Student Questionnaire 1: Section 4) and in May 2014 (Student Questionnaire 2: Section 2) whether or not they felt that students should be given a choice about continuing to study Science at GCSE level. The percentage of students in Class 1 who felt that Science GCSE (or equivalent) should be compulsory stayed relatively stable (2012 = 57%; 2014 = 59%); however, the percentage of Class 2 students who felt that all students should study Science to the age of 16 increased dramatically (2012 = 36%; 2014 = 86%). This increase implies that the students in Class 2 had a substantial shift in their beliefs about the importance of science for all students.

There was an additional element in comments from the students in this study which reflected the importance of their confidence in the teachers' own knowledge in triggering their interest in a topic:

> S1: There was something about like how atoms are like formed and that and someone asked her like how they know that and she just said there was evidence (. .) but she couldn't like say what the evidence was so she just going oh there's evidence they've proven it, the evidence. (She didn't say any more)
> HD: So how did that make you feel in terms of interest in the lesson?
> S1: It kind of made me feel that she didn't know what she was talking about ()
> S2: Yeah.
> S3: If a teacher doesn't understand then it's dead hard for them to make us understand if they don't actually know why they are telling us it. (7 Feb 2013, Student Focus Group Interview)

Furthermore, the teacher's interest in the lesson and the topic, along with positive relationships, were clearly important to the students:

> S1: Like for biology and chemistry I have a better interaction with like you and Mrs X than I do with Mrs Y. Say if you come and talk to us then it is like really like naturally fine but then when Mrs Y comes and talks to us it's like-.
> S2: You're so more approachable and help.
> S1: She just kind of stands there.
> S2: You also like understand so if we get like stuck and we ask you for help you kind of like go through it step by step whereas Mrs Y kind of, because like, we are triple scientists, they kind of expect us to understand all of it and so she'll say

something really quickly she would expect us to follow on. (25 Mar 2014, Student Focus Group Interview)

S1: And some [supply teachers] are just really annoying because they don't even control the class and so most of the time we so we don't even get any work done and we don't learn anything.
S2: That's what it's like for us ().
S3: I don't understand half of what we do in physics.
S1: We just get told to read the book and answer the questions and that's it.
S3: I hate that.
S2: We just watched videos, we watch videos every lesson in physics
S3: They're not even relevant to what we're doing ().
S1: ((laughing)) He's just like "watch the video". (7 Feb 2013, Student Focus Group Interview)

The significance of the student-teacher relationship, as exemplified above, indicates the strong role teachers have to play in supporting the development of students' interest in a particular subject.

One of the most marked changes in students' attitudes was the increase in agreement with the statement 'I am more interested if I put more effort into the lesson' from students in Class 2 (see Figure 6.4). These students went from being ambivalent about this statement to agreeing with it significantly more strongly than they had at the start of the study. In addition, this change in belief about their responsibility for increasing their own interest brings the students in Class 2 in line with the students from the other schools questioned. There was no significant change in the levels of agreement from students in Class 1 with them continuing to agree that both teachers and students were responsible for increasing interest in lessons.

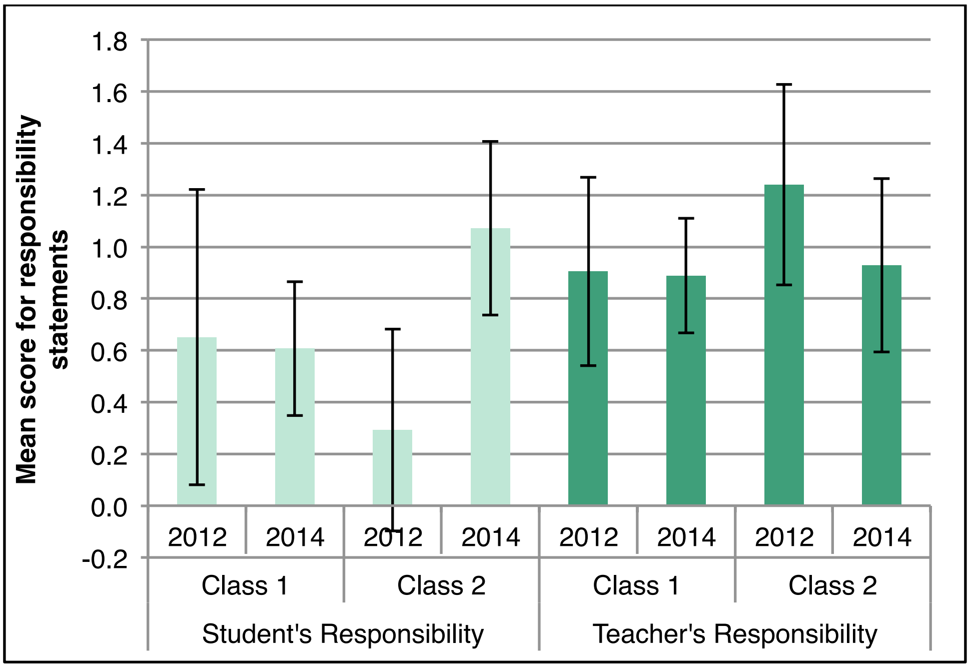


Figure 6.4 Mean responses from students in classes 1 and 2, at the start and end of the data collection period, to who has more of an influence on increasing student interest during lessons (-2 strongly disagree; -1 disagree; 0 neutral; 1 agree; 2 strongly agree).

The level of autonomy afforded to the students is a factor which is closely linked to the students' understanding of the impact their effort and engagement has on their interest in the lessons. If the students do not feel that they have control and choice about their learning they are less likely to take responsibility for their interest and learning. However, teachers felt that there was a tension between 'relinquishing control to the students and pressure to cover the content needed for the examinations' (21 Jun 2013, Teaching and Learning Group Discussion). This point was raised a number of times, in varying contexts, throughout the Stage 2 data. For example, Mrs M commented on the lessons she felt were the most interesting for her:

> The most interesting ones are when I am wandering round and they start asking questions about the topic, you know, for example, we were doing combustion once and I had a picture of a rocket and I had so many questions [from the students] about rockets and fast cars and motorbikes and stuff like that.

> I think I spent about 15 minutes just going round and the boys asking questions about=Mr S: Rockets and motorbikes=yeah, and it wasn't all on task but I thought you know try and get their interest. The problem with that is that you've got an objective to get to and sometimes you can't always get there by doing a free for all. (10 May 2013, Teacher Focus Group Interview)

Teachers are aware of differences and want to increase their understanding of individuals and what strategies could be used to increase their interest:

> Mr S: "What you say doesn't suit everybody." This was then followed by a discussion where all expressed the view that there are some students they would love to know how to get through to and they demonstrated an awareness of the importance of understanding the individuals in the class. (10 Feb 2013, Teacher Focus Group Interview)

As mentioned, one of biggest barriers to creating lessons that increase student interest teachers referred to was a lack of time, both within lessons and, for planning and preparation. For example:

> I would like to introduce more project work to allow them to discover the content on their own but there are time constraints on this, both in lessons and preparation time so it is not possible on a regular basis. (26 Mar 2013, Mrs M Reflective discussion)

However, as the study progressed and different strategies were trialled teachers became more familiar with the Interest Factors and developed strategies for increasing interest which were not time intensive. Specifically, Mrs M started to give students opportunities to work more independently of her guidance (e.g. 12 Dec 2013, Lesson Observation, Class 2) despite this moving her away from her comfort zone: 'The onus was on the students to access the materials provided and do the work ... I found it difficult to not intervene and try to direct them more' (13 Dec 2013, Mrs M Reflective discussion).

Challenges to developing student interest

It was clear, as evidenced by agreeing to participate in the research, that the teachers involved in this study are passionate about supporting their students to increase their interest in science and make good progress. However, a variety of barriers to reaching this aim were raised on a number of occasions. The following list was compiled during one of the Teaching and Learning Group discussions (7 Jun 2013) in an attempt to summarise the key issues teachers felt they faced in increasing interest and personalising learning:

- Time for resource development and teacher discussions
- Curriculum constraints
- How to overcome the 'activation energy' and trigger student interest
- Understanding the students at any one time, e.g. their emotional state.

Time, or lack thereof, is an on-going issue faced by people in many professions and teaching is no exception. As such, one of my concerns at the start of this research was that it would be putting time pressures on colleagues; however, all of the teacher participants said they were happy they had been involved. The setting up of the Teaching and Learning Group, initiated by a teacher participant and attended by teachers from other departments, showed that there was a need and a want for a 'safe space' to discuss and reflect on classroom practice.

The teacher participants, and I, chose to focus on aspects that could be influenced through pedagogy and an increased understanding of students. In light of time constraints, it was agreed that we would consider adapting teaching activities in small ways which could be personalised for each teacher, meaning they were more likely to be adopted and incorporated into lessons. Although there was an acceptance that topics which must be taught were dictated by the relevant examination specification. we endeavoured to reflect upon how the topics we knew students, historically, to be less interested in could be studied in ways to trigger the students' interest.

Teacher engagement with the research

From the outset of the research the teacher participants were enthusiastic about being involved in the study. When asked, during the first teacher focus group interview (9 Nov 2012), what had motivated them to become involved they gave the following reasons:

> Mrs M: Er I think from a personal view I'm always interested in what anybody has got to say and if it makes my interest lasts, if my interest lasts more than thirty seconds then more than likely I am going to be part of it. Also ... because I believe that you are the right person to do it I think your research is interesting and because your motives are good then I want to be part of that now, if somebody's motives are just you want to get a tick on the box then it turns my, [Mr S: UM] it turns me straight away.
>
> Mr S:> it's just it's always interesting I think as teachers we always want to be er expanding the way that we do things and you know you spend so long in the classroom with the class you know doing it the way that you do it so to actually have the opportunity to discuss and to reflect and to er look at it from the different perspective yeah I think the research is (...) somewhat a minor part of it in my opinion as well and it's the er er the means the vehicle to consider things from a different angle and maybe get some input into different ways of doing it

> and different things to think about erm within the classroom erm and having working worked with you for a few years and erm and done bits and pieces you know it's always been interesting it's always been stimulating to reflect on how we do things.
>
> Mr T: I think I'd agree with all of that, yeah, nothing else to add. (9 Nov 2012, Teacher Focus Group Interview)

The level of engagement over the two years of Stage 2 of the method varied between the teacher participants for a number of reasons. Mr T left at the end of the 2012/2013 academic year to work at another school, but still showed an interest in the research and took part in a reflective discussion during July 2014. Due to timetable constraints, it was more difficult to observe lessons taught by Mr S, and although he did not attend as many of the Teaching and Learning group meetings he often instigated informal discussions regarding strategies he was thinking of trying in his lessons. Mrs M was involved in all of the Teaching and Learning group meetings, was extremely interested in the research and clearly enjoyed having the opportunity to discuss the issues raised.

The on-going involvement of the teachers speaks to the success of the activities developed to allow teachers to engage in reflection. The coupling of reflective discussions with lesson observations was considered to be particularly useful by the teacher participants, as Mr S put it:

> It was useful to have you in the lesson, like peer reviewing, and was more useful than just having a discussion, as teaching is more than that; you need to focus on how you approach things and how they manifest in the classroom. (13 Dec 2013, Mr S Reflective discussion)

Similarly, the teachers all reported that they found the Teaching and Learning group sessions useful and stimulating with the only negative feedback relating to regret that, due to constraints, and other demands on time, we had been unable to meet formally as a group during the middle of the 2013/2014 academic year (Oct to May).

6.4 Discussion

Engaging in reflective practice

Developing our use of rigorous reflective practice was seen as important if we were to be effective in our goal of adjusting our teaching practice and assessing the impact these adjustments had on student interest. During the first Teacher focus group interview the teachers were asked about their previous experiences of reflective practice and coaching/mentoring both within and outside the school setting. Once the teachers had shared these experiences the discussion moved on to explore the meaning, and importance, of 'effective reflective practice'. Reflective practice can be interpreted in a number of different ways along a spectrum from 'pondering trivial details' to 'systematic data analysis' (McLaughlin, 1999). For reflection to be effective it must critically engage with the object of that reflection. Where there is no clear working definition which is communicated to all involved it becomes challenging to share good practice and difficult to develop practice which can be considered reflective (Heilbronn, 2008b).

One key factor in becoming a reflective practitioner is the ability to see things from the learners' perspectives (Heilbronn, 2008b) and therefore the 'listening' to student voice and communicating effectively and regularly with learners is crucial for teachers. In the context of this study the responses from Student Questionnaire 1 were used as the initial 'student voice' to shape the strategies developed for increasing student interest. As Stage 2 of the method progressed, 'student voice' from both the student focus group interviews and discussions in lessons was drawn upon to assess the impact of interventions and shape the Teaching and Learning group, and Reflective discussions.

A teacher's internal viewpoints will strongly influence their expectations and behaviours in a science lesson. Such views include their personal interest in a subject and their expectations of certain groups of students. It is therefore vital that a teacher engages in active and effective reflection to reduce the impact of bias in their internal viewpoints of their classroom practice. As evidenced in Section 5.5, there is a mismatch between the views of students, regarding the effect of the Interest Factors, and the teachers' understanding of those views. Where the students are in ability set 1 the difference between students' and teachers' responses is minimal; however, there are a number of substantial differences between the responses from teachers and students in ability set 4. The most significant of these is how strongly teachers agree with *Control, Personal endeavour, Modelling* and *Exploring science*, compared to the neutral, or negative, scores for these three factors from the set 4 students. Although some of these differences could be the result of teachers being asked to respond based upon 'what students think' rather than what 'students in set 4 think', they still highlight a potential gap in teachers' understanding of student views (see Section 5.6 for further discussion).

One aim of the approach employed in this study was to gain insight into teachers' understanding of the importance of providing, and how to, support the development of student interest. At the same time it provided them with an opportunity to reflect on their teaching through the use of reflective discussions after each lesson observation. This aim was achieved and the teachers valued the opportunity to discuss their lessons in this way. Although the setting up of the Teaching and Learning group was not part of the original plan for this research it became an integral part. This group of “critical friends” (Campbell, McNamara and Gilroy, 2004, p. 107) provided the setting for teachers to discuss views of teaching and learning, with a specific focus on developing student interest, in a non-judgemental environment. It was important for these discussions to be held outside of the school’s performance management structure to allow teachers to feel comfortable enough to express ideas without fear of reprisal if these views differed from those valued by senior management (Campbell, McNamara and Gilroy, 2004).

Time is always a pressure, be it perceived or real, and I was very concerned about adding to teachers’ workloads through lunchtime or after-school meetings. As a result of this no meetings were held after school and lunchtime meetings were only held when there were no other meetings in a particular week; therefore, there were some weeks where we could not find an opportunity to meet when we were all free at the same time. However, it was clear from this research that what the teachers involved wanted and required was time to work with other teachers, enabling them to develop their own understanding of pedagogy, their confidence and their ability to deliver outstanding lessons. Despite being fully committed to the importance of reflective practice I made the following note during the summer of 2013:

> At the end of the year there are so many pressures on time it is difficult to find time to relax and reflect, on an individual basis, on the achievements which have been made over the last year and how you may want to develop your teaching practice next year. I have managed to arrange time to speak to [Mr T] and will do my own reflections over the summer but how much will other staff do? [Mrs M] has agreed that it would be useful to meet over the summer holidays to discuss

aspects of teaching and learning. (23 Jul 2013, Personal Reflection)

Due to a range of factors Mrs M and I did not manage to meet up over the summer holidays but instead started Teaching and Learning Group meetings in September 2013. The opportunity provided by the Teaching and Learning group meetings was seen as beneficial by all involved. During the academic year 2014/2015 another group was started, within school, by a member of staff as part of her work for the National Professional Qualification for Senior Leadership (National College for Teaching and Leadership, 2014). This group was called the ‘Teaching and Learning (Outstanding) Development Group’, the aim of which was to share good practice across departments and create a ‘directory of expertise’ which could be shared with all staff. Any teacher who had achieved an ‘outstanding’ lesson observation as part of the previous year’s performance management cycle was invited to join. I was part of the group and although it achieved its aims felt that it was not as personally rewarding due to the large number of staff, meaning that discussions were very general and directed by the group leader, rather than being a more open forum for teachers to raise their own questions. In addition, the teachers who were invited to join this group were selected based on performance management reviews, so other teachers were excluded.

A number of the interactions I had with teachers during this project emphasised the importance of trust and mutual respect between colleagues. For example, in October 2012 Mrs M asked me if I would be willing to discuss some coaching work she was doing with her sixth-form students. As part of this discussion she expressed the opinion that she felt there was no one else within the school that she could talk about this sort of activity without them viewing it from a whole school or performance management perspective and therefore she perceived this to add pressure and limit her willingness to experiment with teaching and learning strategies. Mr S also expressed similar views with regards to the importance of trusting the colleagues you are working with when reflecting on his experience of a recent coaching triad he had been working with:

> I felt that was, you know, that was a good experience that was useful erm and we were able to talk honestly >but it depends< on having people who you are prepared to share and can be constructive with. (9 Nov 2012, Teacher Focus Group Interview)

Furthermore, the teachers expressed a need for understanding the reasoning behind why they should try out new teaching initiatives as they felt that without this understanding the strategies could not be internalised and therefore personalised to become an effective part of a teacher's practice.

Given the high profile of GCSE results (Denscombe, 2000), teachers can feel under pressure to ensure their students perform well in examinations and therefore feel constrained and overwhelmed by the volume of content which must be covered as part of the specification. The schemes of work which were being used by the science department of School A, at the time of this research, were published by the examination board and were perceived to be very structured and limiting, both with regards to permissible activities and to timings for covering content, often moving on to a new topic every couple of lessons. Through this research, we were able to develop an awareness of students' views of what influences their interest in learning science which in turn led to adjustments in teaching which could be incorporated into the lessons in an attempt to combat the negative impact of these restrictions.

Students' levels of interest

The stability of students' Individual Interest is not surprising as this is accepted to be fairly consistent, having developed over time (Ainley, Hillman and Hidi, 2002). However, having increased the students' Situational Interest during this two-year period an increase in Individual Interest may follow if students continue to reengage with science activities. The marked increased in the number of students wanting to continue to study either science or other STEM subjects indicates that the increase in Situational Interest was resulting in students wanting to re-engage with the content, a characteristic of the development of Individual Interest.

This study suggests that although students' interest did not increase significantly, it was possible to make small gains in both the Situational Interest and Individual Interest of the students in Classes 1 and 2. Building relationships, which has been shown to be important to students through their strong agreement with the *Learning from others* Interest Factor, could have an impact on their enjoyment of learning science, and therefore their interest in the lessons. Generally, classes are assigned three teachers for the two years of their GCSE course, and therefore see each teacher three times a fortnight for two years, whereas they are likely to have had a different teacher for each of the three previous years. This allows the teachers and the students to get to know each other during the GCSE course and develop a better understanding of teaching and learning preferences. Alternatively, the increased interest could have been an artefact of the students' involvement in the research itself. Certainly, the students were interested in what was being done and why and often asked questions about the process and the preliminary findings. Therefore, they may be a version of the Hawthorne effect at play, as was also concluded by Logan and Skamp (2008) in their study of interest across the primary-secondary school transition period. However, the presence of the Hawthorne effect does not, in itself, reduce the validity of the study; rather, it highlights an additional factor which may increase student interest, namely involving them in research about teaching and learning. Unfortunately, due to constraints of data collection, there is no evidence available to show if the trend in interest levels was seen in all groups of students, not just those involved in Stage 2 of the study, and therefore the conclusions as to cause of these results are restricted.

The upward shift in the percentage (36% to 86%) of students in Class 2 who believed that science should be compulsory at GCSE level suggests that these students have increased their understanding of the purpose of studying science at this level and believe it to be important. It was especially notable that this increase occurred in Class 2, only 58% of whom were considering continuing with STEM subjects after their GCSEs, and that no such increase occurred for the students in Class 1, 96% of whom were considering going on to further STEM study. The reasons given for believing that science should be compulsory all centred around the theme of 'it is important for everyday life / it is basic knowledge'. Similarly, the reasons given for students being allowed a choice whether or not to study science mostly followed the theme of 'if you don't need it for a job you shouldn't have to do it', although a small number focused on the idea that if a student does not enjoy the subject they may disrupt the learning of others. These responses are intriguing, given the high proportion of students in Class 1 who were planning on studying STEM subjects in the future, and almost suggest an attitude of 'science is for me, but not for others'.

Strategies to increase interest including the role of practical work

A number of specific strategies which were used to adapt teaching are described in Section 6.3. However, given the importance of *Learning from others* and *Personal endeavour* reported by the students, there was a general focus on both the roles which providing clear learning objectives to the students and group work could play in the development of interest.

From the outset of this research it was accepted that given the current emphasis on student progress and attainment at 16 years of age there is very little, if any, flexibility with regards to what content can be taught to the students. This content has been, since 1989, laid out in the various iterations of the National Curriculum for England, most recently revised in 2014, (Department for Education, 2015) and then interpreted by Examination Boards to produce GCSE specifications (or other Level 2 qualifications). More recently, the Department for Education in England has provided specific details as to what content must be included in GCSE specifications (Department for Education, 2015). The focus was on the activities and classroom strategies which could be employed to increase student interest (see Section 6.3). Sharing the expected learning outcomes or success criteria has been shown to be particularly effective in increasing student learning (Versey, 2006); it was also shown here to increase student interest. Furthermore, strategies which required students to reflect on their progress with regards to the learning outcomes appeared to further increase student interest. It is possible that knowing that they have made progress increases or emphasises *Personal endeavour.*

Learning from others was the most strongly agreed with Interest Factor, although the broad nature of this research did not allow for in-depth study into how different forms of peer education can increase student interest (for discussions see Blatchford *et al.*, 2003; Damon and Phelps, 1989). There is, however, enough evidence to suggest that the effective management of group work; taking into account which students are grouped together, the specific activities completed and expected outcomes, is an area worthy of further study with regards to its impact on student interest.

Practical work is not a component of any of the Interest Factors generated by responses to Student Questionnaire 1: Section 2. 'Carrying out practical work' was, however, the second most strongly agreed with individual statement. This, together with the importance of practical work in science lessons, meant that particular attention was given, by the participating teachers, to the use of practical work as a vehicle for increasing student interest. Specifically, how planned practical tasks could be adjusted to incorporate aspects of the Interest Factors (Darlington, 2015).

Practical work provides a perfect opportunity for students to engage and learn from their peer group as it is often carried out in small groups. All of the students involved in this research study felt that working in small groups benefited their learning and increased their interest in learning science. There were a number of reasons for this, including feeling that they could ask questions without anyone judging them for asking. However, how these groups are constructed must be carefully considered. Generally, the students in the study felt they were most comfortable working in friendship groups, with students they could communicate well with or who had the same level of engagement with the task. Allowing the students to work with those whom they choose may also provide students with an appropriate level of challenge for the task as their peers will naturally ask questions with differing levels of challenge.

Although many of the Interest Factors interact it is clear to see the importance students place on 'control', both in terms of understanding what they should be doing and choosing how they want to present information. If students can believe that they have helped to shape the lesson or the activity, for example, choosing the variables to investigate or the method they will use, then they are going to be significantly more interested in the outcome of the experiment since they are being given the opportunity to answer the questions they want to answer. From the students' responses it was clear that it is also important for them to have control over procedural aspects of the lesson, even if that control is just an understanding of the teacher's expectations for the lesson.

Allowing students space to shape a task and to choose which aspect of a topic they would like to explore is one way of increasing student interest through *Personal endeavour.* Practical work can allow students to shape a task and therefore, within obvious limits, make a task more relevant to themselves and the questions they want to answer. However, this factor goes deeper than *Control* with regards to the personalisation of learning for the students. They need to feel confident that they have some knowledge in an area and are capable of understanding more, emphasising the importance they place on feedback. Practical work provides many opportunities for students to feel they can apply prior knowledge since students are often confident manipulating basic laboratory equipment. Furthermore, students will become more interested, in the activity specifically or in science in general, if they receive focused and insightful feedback on their work and progress. Seeing the results of an experiment can provide this to some extent but time must also be built into practical tasks to provide explicit feedback on specific parts of the task, for example, if students have selected the range of measurements to collect they should be given time to reflect on these choices.

Teachers have seen the results of experiments dozens of times and therefore often forget that the students, for the most part, have not. Therefore each experiment is a puzzle of some sort for students to solve. They may have formulated a strong hypothesis based on their prior learning but one purpose of carrying out the practical is to test this hypothesis. Therefore, the biggest trap to avoid is for the teacher to be nonchalant about the task and what the findings may be. Investigative work, with a little planning, provides a range of opportunities for solving puzzles. For example, students could be presented with a range of equipment and asked to work out how they could use it to test a hypothesis or students could be shown a range of unusual results or intriguing phenomena and ask to explain them.

To be most effective *Modelling,* both physically and conceptually, should be incorporated once students have Emerging Individual Interest as it can be considered as providing a high level of cognitive challenge for students since they are required to take abstract concepts and explain them in more concrete forms. It therefore requires a deep understanding of the underlying theoretical idea, high self-efficacy and the willingness to tackle higher levels of challenge. It can, however, have a strong affective component as well, especially if students are physically engaged in an activity such as building an artefact or presentation through drama. With regards to practical work, modelling is most useful for developing predictions, interpretation of data and application of theoretical explanations and allows students to activity participate to a level they are comfortable with.

Students agreed least strongly with the *Exploring science* Interest Factor, and unsurprisingly this was strongly correlated with which ability set students were placed in. However, for most students there are some aspects of science that they do find interesting and want to explore in more depth. For students who have reached the Well-developed Individual Interest phase practical work allows them to add a further dimension to their understanding of science for the reasons discussed above. On the other hand, for those students who have not yet developed Individual Interest practical work can offer opportunities to open the world of science up to them as they can ask questions, carry out relevant experiments and make surprising observations, which can then be used as a starting point for increasing the level of cognitive challenge provided.

By considering the Interest Factors described above, practical tasks can be developed to increase student interest and as a result of this have a positive impact on students' desire to engage with scientific theory and investigation, which in turn should lead to deeper understanding and increased attainment. However, the fact of 'doing practical' may trigger Situational Interest but it is unlikely to maintain or develop this interest (Abrahams, 2009), unless teachers consider what they are asking the students to do in the context of the Interest Factors. The potential of practical work to develop students' interest can be realised, or not, through one vital activity – effective planning. In previous research (SCORE, 2008) teachers reported most frequently that they plan practical work into lessons to teach skills and motivate students, with less than 40% of teachers employing it as a method of teaching concepts or encouraging scientific enquiry. In addition, Abrahams and Miller (2008) analysed 25 case study lessons involving practical work and found that the learning outcome was most often the students being able to manipulate equipment, rather than apply scientific theory to interpret findings.

As stated above interest incorporates both affective and cognitive components and therefore if students can be supported in developing Situational, and particularly Individual, Interest through practical work it provides an opportunity to present students with greater challenge and therefore deepen and extend their knowledge. However, this cognitive challenge needs to be planned for and considered carefully to ensure students can access this content. If teachers are not aware of this it is too easy for practical work to become all about the affective aspects of interest with little cognitive engagement, as demonstrated by this quote from a Year 11 student during a practical lesson: "this is an amazing blue; I wish my eyes were this colour". The student who said this had not read the method sheet and had relied on other students to collect the equipment and carry out the experiment and, although at the moment she said this she was fully absorbed in the results of the reaction, it is difficult to believe that she had gained much, if any, scientific understanding from this piece of practical work. In addition, if there is no cognitive challenge present in an activity students are unlikely to develop Situational Interest during the lesson and if there is no Situational Interest triggered, students are less likely to develop Individual Interest in the future.

One possible additional explanation for students' engagement and interest in practical work might actually be that they interpret 'practical work' even more broadly than the definition given above. The active and explicitly participatory facet of practical work may be the underlying feature of practical work that encourages and supports interest development. It is therefore important that further research is done in this area to deepen our understanding of student interest, how best to support its development and methods of ensuring differentiation to allow personalisation of lessons.

The evidence presented in this chapter strongly suggests that it is possible, though adjusting teaching methods, to increase students' levels of Situational Interest throughout the two years of their GCSE study. The increase in the proportion of students from Classes 1 and 2 who say that they intend to continue to study science, and/or other STEM, subjects indicates that the adjustments which were made had a positive outcome in encouraging students to re-engage with these subjects. Although there was no impact on the students' Individual Interest, previous research (Hidi and Renninger, 2006) suggests that the increase in Situational Interest will help to maintain the current levels, or even lead to an increase, of Individual Interest over time.

The teacher participants were enthusiastic about being involved in this research and being given an opportunity to reflect upon and develop their teaching in order to support the development of student interest. It is rewarding for teachers to engage in reflection; however, there are often barriers which must be overcome to allow time and space for this reflection.

The final chapter draws together the key conclusions of this thesis as well as exploring aspects which need to be considered in the wider contexts of interest and science education research. The limitations of the current study are discussed along with suggestions of areas which require further investigation.

Chapter 7: Overall conclusions, evaluation and areas for further research

7.1 Conclusions

The overall rationale for increasing interest in science lessons is to enhance students' awareness and appreciation of the scientific endeavour and the knowledge and understanding of the world that has resulted over the centuries. This rationale includes the ways in which students perceive and value the place of science in their culture and the contributions scientists have made to improving society and the quality of life that we all experience. In the context of school science, students' levels of interest are often assessed using narrower criteria, namely student attainment in science subjects and the number of them choosing to continue with their science education leading to a career in science or a science-related field. There is a long history of research papers calling for the need to increase student interest in science lessons in order to achieve all of these aims (for example, Hulleman and Harackiewicz, 2009). However, many of these papers have used an everyday understanding of 'interest'. In recent years, our understanding of interest has increased significantly through both empirical studies and the development of theoretical models, one of which, the Four-Phase model of interest development (Hidi and Renninger, 2006) underpins the current study.

The context of the study was science education for 14 to 16 year-old students in England, specifically, what students and teachers believe influence students' interest levels. In total, five research questions were investigated:

- What factors do students believe influence their interest in learning science between 14 and 16 years of age and does a student's school, gender or ability grouping relate to these beliefs?

- What do students believe is the purpose of studying science between 14 and 16 years of age and does a student's school, gender or ability grouping relate to these beliefs?
- To what extent are teachers aware of 14 to 16 year-old students' beliefs regarding factors which influence interest in, and the purpose of, studying science?
- Is it possible to increase students' interest, specifically their Situational Interest, in learning science through adjustments to existing approaches to teaching?
- How can teachers be supported in developing their classroom practice with a view to increasing students' interest levels?

The key conclusions for each of these questions are presented below.

What factors do students believe influence their interest in learning science between 14 and 16 years of age?

Students have clear ideas about factors which will support the development of, and increase, their interest in learning science. Six Interest Factors have been identified by conducting a factor analysis on the responses of 475 students to Student Questionnaire 1: Section 1 (see Appendix 1). These factors are: *Learning from others*; *Personal endeavour*; *Control*; *Puzzles*; *Modelling*; and *Exploring science.* In general, students believe that the first three of these factors will increase their interest in science lessons. Students believe that *Learning from others* will have the greatest positive effect on increasing interest which suggests that greater emphasis may need to be placed upon the role of (peer) social interactions and cultural context than is reflected in the Four-Phase model of interest (Hidi and Renninger, 2006).

Although students from all four schools in the study have similar levels of agreement with the factors there is some variation; for example, students from School D agreed with *Modelling* even though students from Schools A and B did not. This may be the result of different levels of exposure to certain teaching strategies or to differences in the overall school ethos and approach to science lessons. Apart from *Exploring science*, female students are more likely than male students to agree that each of the factors will increase their interest in learning science. The ability set a student is in appears to have the greatest effect on how they perceive the impact of the Interest Factors; the higher the ability set the more likely students are to agree that each of the factors will increase their interest in learning science. Students in the lowest ability set are much more likely to be ambivalent about the impact that any of these factors will have on their interest levels.

The role of practical work in increasing levels of interest appears to be an anomaly. Practical work is a key component of science lessons, at any stage of schooling, and students agree that it does increase their interest levels Indeed, practical work was the highest rated individual item but, following the factor analysis, did not cluster into any of the Interest Factors. However, previous research (Abrahams, 2009) indicates that although practical work may trigger Situational Interest it will not, in-and-of-itself, maintain it, nor lead to Individual Interest, unless the practical activities are underpinned by greater focus on the Interest Factors identified here. Although students appreciate and enjoy carrying out practical work, its potential to increase their interest through both affective and cognitive components is often unfulfilled. To maximise the impact, potential activities must be carefully planned with clear objectives and considered within a broader definition of 'practical work'. This would allow students to be exposed to a wider range of the Interest Factors including *Control* and *Puzzles*, thus involving students in their learning, increasing their sense of autonomy and helping them to understand why they are learning specific content. If the Interest Factors, identified in this study, are taken into consideration when planning practical work, the tasks will naturally become more open and investigation-based, helping students to develop a deeper understanding of scientific processes as well as increasing their interest in 'doing science' and exploring the world around them.

What do students believe is the purpose of studying science between 14 and 16 years of age?

Stage 1 of this study generated four Purpose Factors: *Professional relevance; Developing knowledge; Social relevance;* and *Personal relevance.* These were generated by conducting a factor analysis on the students' responses to Student Questionnaire 1: Section 2. However, the students, on average, only agreed with the first two of these being purposes of studying science at GCSE level. Students' strength of agreement with the Purpose Factors is not affected by the school which they attend and there are no gender differences. However, there are significant differences in the level of agreement reported by students in different ability groups. Students who are placed in the lower ability groups do not agree that any of the Purpose Factors are reasons why they study science between the ages of 14 and 16 years-old. This will clearly have implications for the students' interest levels as they may struggle to identify activities as being meaningful either to them personally or more generally.

There are strong positive relationships between students' levels of interest in studying science and their recognition of *Personal relevance* as a purpose of studying science. Therefore, it is possible that if a teacher can support students in identifying the *Personal relevance* in their learning of science it may increase the chance of triggering their Situational Interest and vice versa. This relationship may continue to propagate students' interest in learning science and, as the Four-Phase model of interest states, support the development of the students' interest through the phases to 'Well-developed Individual Interest'. The strong positive correlations between interest level, *Personal relevance* and the Interest Factors suggest that once a student has some interest in learning science they are more likely to agree that taking part in activities that support their learning will further increase their interest levels. Furthermore, the higher a student's interest in learning science the more likely they are to accept responsibility for that interest and believe that it is not the teacher's job to make the lesson interesting but in fact it is their level of engagement which influences how interesting they find the lesson.

This study provided no evidence of relationships between students' interest levels and the extent to which they believe that the purpose of learning science is *Professional relevance, Developing knowledge* or *Social relevance*, although if they perceive one of these to be a purpose of learning science they are likely to agree that they all are. It is therefore possible for students to see that there are important reasons for learning science but to have no interest in learning it. This is not to say that these Purpose Factors should be ignored when considering teaching strategies because if a student can identify with one of them it is more likely to make the learning more meaningful to them which in turn may start to trigger interest.

To what extent are teachers aware of 14 to 16 year-old students' beliefs regarding factors which influence interest in, and the purpose of, studying science?

There is little, if any, research which investigates the extent to which teachers understand the views of their students with regards to what makes science lessons interesting or why science is studied between the ages of 14 and 16 years. This study aimed to do exactly that and found that there is typically a mismatch between what the teachers believe students think and what students actually state that they think. Teachers believe that students feel the Interest Factors will have a greater positive impact on their interest levels than is in fact the case. Similarly, the teachers thought the students would see a greater range of purpose for studying science GCSE and believed that students would agree more strongly with *Professional relevance* and *Developing knowledge.* Furthermore, responses from teachers are more similar to those of the more able (set 1) students than the less able (set 4) students. These findings suggest that teachers need to spend more time discussing pedagogy with students in order to understand what can increase their interest. This is particularly important for students in lower ability sets where there is the greatest discrepancy between teachers' and students' responses. Teachers need to increase their awareness of student attitudes to maximise the possibility of increasing interest for the less able students.

A key underlying principle of this research is that there is great value to be gained by all teachers in listening to students and using student voice to inform teaching and learning in classrooms. However, to be effective teachers need to be open to student voice in its many guises, not just as formal responses to questionnaires or interviews. A key example of this is the discrepancy between student questionnaire responses to the Interest Factor of *Puzzles*, which suggested they were ambivalent about the value of puzzles in increasing their interest in science, and the behaviour of students in lessons when carrying out puzzle-based activities which demonstrated that the activity was, in fact, triggering Situational Interest. The students who took part in this study showed that when they are invested in their learning, students want to be involved in shaping it and discussing their views with teachers. Furthermore, being given the opportunity to share their views may encourage them to become more engaged and interested in learning science. This may in fact be a version of the Hawthorne effect, as suggested by Logan and Skamp (2008) in their study of student interest in science over the transition from primary school to secondary school. However, there is still a positive impact of student interest in lessons and therefore active engagement of students in research should be embraced, even if it does result in a form of the Hawthorne effect. It can only be considered a good thing if engagement with the research afforded the students an opportunity to reflect upon the importance of science or supported them in increasing their self-esteem / self-efficacy and wider motivation with regards to studying science. The shifts in students' attitudes towards learning science may be a result of formalising the use of student voice and empowering students to have a voice through providing clear reasons for why they are being asked about their lessons. In other words, they can see a purpose for engaging with the problem.

How can teachers be supported in developing their classroom practice with a view to increasing students' interest levels?

The initial aim of this research was to collect data to increase our understanding of what factors students believe increase their interest in learning science and the extent to which teachers understand these. However, the teacher participants agreed to develop this further and allow investigation as to whether or not the findings from Stage 1 and early Stage 2 could be applied in the classroom to actually increase the interest of students in their lessons. The teacher participants fully embraced the opportunity to be part of this study for a number of key reasons. Perhaps, most importantly, like the students they could see a purpose to the activity. It is well documented in both research (for example, Kyriacou, 2001) and the media (for example, Marsh, 2016) that teachers feel there are severe time pressures placed upon them. However, the teachers in this study willingly attended lunchtime meetings and engaged in informal conversations regarding the research and the students. The research was fully inclusive and asked for teachers to volunteer for the study; therefore, there was no pressure and no one was 'telling them they had to do this'. As a result of this, the work was completed outside of the performance management structure of the school, thus removing the potential for teachers to be penalised if they chose not to continue and helping teachers feel comfortable in undertaking critical reflection. Teachers were supported through taking part in reflective discussions following lesson observations, as well as being part of a mutually supportive group of teachers who met to discuss the relevant issues in a non-threatening manner. Perhaps one of the most important aspects of this was the time taken to look at some 'live' data/evidence (specific to their school) and build on it rather than on just a 'hunch' or on information from elsewhere.

Is it possible to increase students' interest, specifically their Situational Interest, in learning science through adjustments to existing approaches to teaching?

Stage 2 of this study has shown that it is possible to increase student interest in learning science by considering the students' views towards the Interest Factors, acting on them and incorporating them into lessons. The students' responses and behaviours were analysed and interpreted in order to adjust teachers' existing pedagogy in simple, yet significant, ways, leading to a significant cumulative effect on student interest levels.

There is a clear relationship between the level of interest a student has and where they see the influence and responsibility for developing that interest lies – either with the student themselves or with the teacher. Where student interest increased so too did their understanding that they are more interested in a lesson when they put in more effort. This is likely to be linked to a student's sense of self-efficacy which, in turn, is strongly linked to the level of control students have in lessons and their knowledge and understanding of a subject (Friedel *et al.*, 2007). As with other aspects of interest development there appears to be a positive feedback loop as shown in Figure 7.1 in which increased effort leads to increased self-efficacy, which in turn leads to increased interest and further effort and so on.

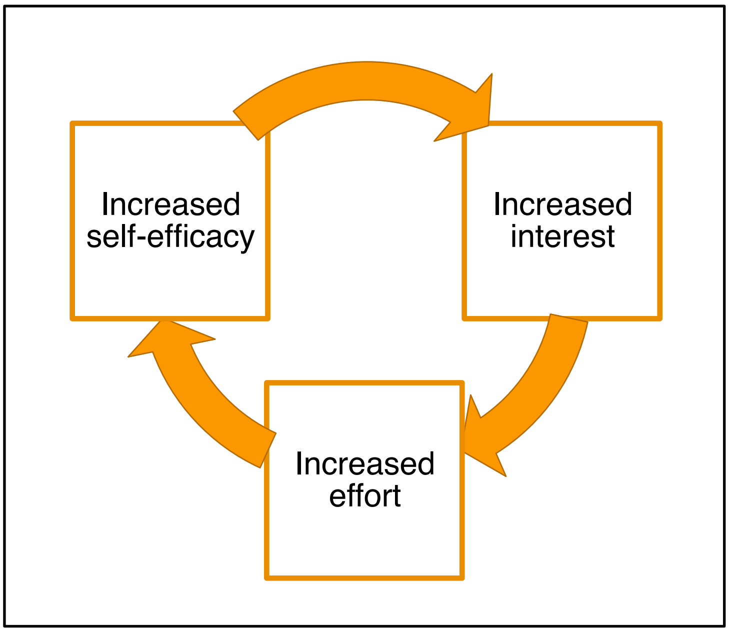


Figure 7.1 The positive-feedback loop between interest, effort and self-efficacy.

Control, one of the key Interest Factors identified by students in this study, has strong parallels with what Niemiec and Ryan (2009) call autonomy. However, incorporating this factor into lessons can be perceived as challenging and even daunting for teachers, especially if they feel external pressures are restricting their own autonomy (Pelletier, Séguin-Lévesque and Legault, 2002). There is a growing body of evidence to suggest that underpinning the autonomy-supportive classroom is the importance of "high quality interpersonal relationships – relationships rich in attunement and supportiveness" (Reeve and Jang, 2006, p. 217). Through these relationships it is possible for students to start to develop their own sense of autonomy as teachers feel less of a need "to take charge of the teaching situation so as to shape students toward the correct answers and desired ways of behaving" (Reeve and Jang, 2006, p. 217).

7.2 Placing these conclusions in the wider context

The results of this study offer further support to the Four-Phase model of interest development (Hidi and Renninger, 2006) as the majority of students had higher Situational Interest than Individual Interest. However, this model does not easily explain why some students have lower Situational than Individual Interest. It may be the case that there is a positive feedback loop, or spiralling of interest, where Situational Interest needs to be triggered and maintained on a regular basis to continually support the development of Individual Interest. This may be true for all age groups or have greater importance for students at different stages during their school and professional lives. The need to re-enforce Situational Interest may also be more likely in certain subject areas; for example, in science at least three domains and numerous topics are covered and revisited throughout a student's schooling. The need to trigger, maintain and re-enforce Situational Interest may also be of particular importance for students of lower academic ability. Not only do these students tend to have low self-esteem, they also consider a subject such as science to be for the more able students and therefore not for them.

In addition, the findings on the interest levels of students, at least for this age group, provide evidence against the Model of Domain Learning (Alexander, 2004) which states that Situational Interest will drop as Mastery increases. When analysed by ability set it was found that, whatever their abilities, students have similar levels of Situational Interest, whereas Alexander's (2004) model would predict that the most able students would have lower Situational Interest than Individual Interest in response to an increased mastery of the content. Similarly, the Model of Domain Learning predicts that Situational Interest will be higher than Individual Interest in those students with a lower level of mastery; this was not the case for students in the lower ability sets. The difference between Alexander's findings and mine may be down to the students' age or due to the students in my study covering a narrow range of overall Mastery level, thus not representing the spread of developmental stages found in Alexander (2004).

There is considerable evidence, from both the findings of this study and previous research (for example, Hulleman and Harackiewicz, 2009; Ryan and Grolnick, 1986) that the relationship between interest, knowledge and self-efficacy, and their underlying factors, is key in supporting students' cognitive and emotional development. For example, self-determination theory states that competence is one of the key factors in allowing students to internalise external motivators and thus develop interest (Deci, 2015). Ryan and Grolnick (1986) found a correlation between self-efficacy and interest. Other research has found that students' attitudes to science (interest levels) and how 'good' students feel they are at science (self-efficacy) "are the factors that seem to have the strongest relationship to student science aspirations" (Archer *et al.*, 2013, p. 12). This conclusion is supported by the current study however an additional observation was that female students reported lower interest levels than male students. Previous research (for example, Murphy and Whitelegg, 2006) has found that interest and self-efficacy levels in science of female students decline as they progress through formal schooling.

In addition, a number of factors which are cited as supporting the development of interest have also been shown to be key factors in students' self-efficacy. Specifically, students in this study agreed that *Learning from others, Personal endeavour* and *Control* are important in developing their interest, which parallels the importance of autonomy (Niemiec and Ryan, 2009) and social support and mastery experiences (Bandura, 1994) in developing a sense of self-efficacy. Therefore, through incorporating the three Interest Factors identified by students as increasing their interest into science lessons, it is proposed that teachers would not only increase students' interest levels but also support the development of high self-efficacy. Ultimately, this should often lead to improved progress and attainment for students.

Figure 7.2 has been developed to show the relationship between learning (i.e. developing new knowledge), interest and self-efficacy through the integration of existing research and the findings of this study. More specifically it shows how the Interest Factors, generated during the current study, contribute to developing interest and self-efficacy alongside emotional capacities described by Bandura (1994).

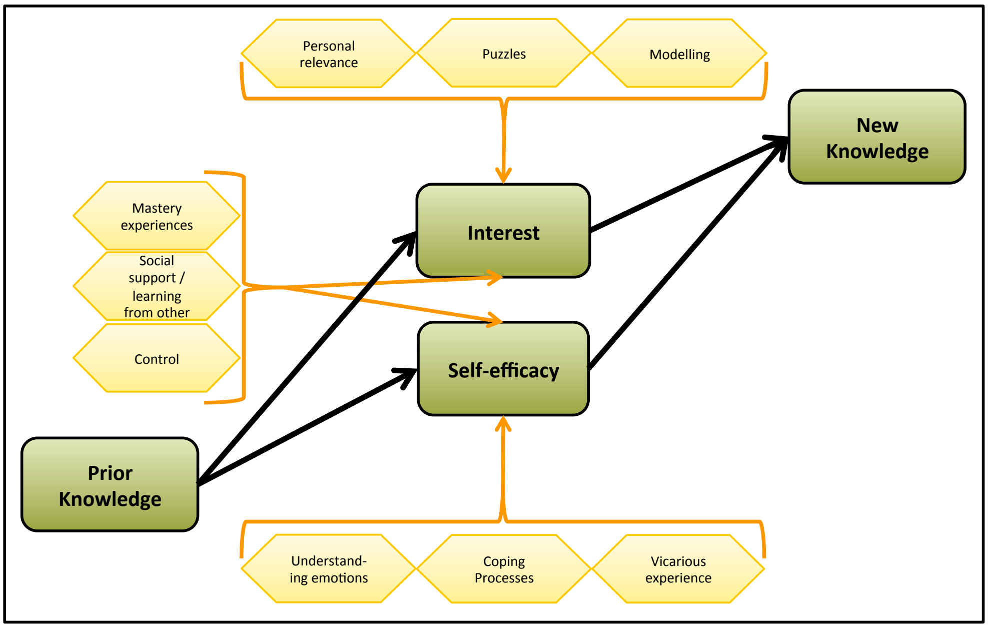


Figure 7.2 The link between Interest, Self-efficacy and Knowledge and factors which contribute to these key constructs. Based upon the Interest Factors developed in the current study and existing research.

Despite the increased interest demonstrated by the students in this study there was still only a small proportion of students from Class 2 considering further science study. It can therefore be assumed that there are only a small number of these students considering science-related careers. Reasons for this may be that the increase in interest in science was triggered after they already had well-developed Individual Interest in another domain, or that they believed that they were 'better' at other subjects. Alternatively, the 'science capital' in these families may be lower:

> Science capital refers to science-related qualifications, understanding, knowledge (about science and 'how it works'), interest and social contacts (e.g. knowing someone who works in a science-related job) ... Students from families with

> medium or high science capital are more likely to aspire to science and STEM-related careers and are more likely to plan to study science post-16. (Archer *et al.*, 2013, p. 3)

The ASPIRES report calls for a 'shift [in] the policy discourse' (Archer *et al.*, 2013, p. 4) to build science capital, not only with students but also with adults. The role that adults such as parents and relatives, not just teachers, have in influencing a student's choice to continue with science study or enter a science-based profession is also highlighted by Rodd, Reiss and Mujtaba (2013). The main influence on whether or not someone started an undergraduate physics course was their identification with a key person who believed that it was worth studying physics and that they were able to do so (Rodd, Reiss and Mujtaba, 2013). The importance of key people may go some way to explain why the students in this study said that *Learning from others* is the most important fact in increasing their interest in science lessons. It may be the human need for social interaction and emotional engagement which drives the affective component of learning science:

> This process of taking in another's mind may relate to social aspects of learning in situations where there is a group attraction to characters – whether particular teachers at school or media celebrities; the group reinforces and helps to construct the process. (Rodd, Reiss and Mujtaba, 2013, p. 165)

Similarly, the role of others might explain why students are ambivalent about the impact of *Exploring science* on increasing their interest since the curriculum they are following focuses on the theories and processes in the natural world and, for the most part, ignores the scientists, the people and characters, who contributed to this body of knowledge.

7.3 Evaluation of this research

This study has focused solely on students between 14 and 16 years old studying towards a Science GCSE qualification as this was the only qualification offered to the students in the participating schools at the time of the data collection. The highly contextualised nature of this study provides valid data with regards to student interest in science as interest, by its very nature, is highly contextualised. Although this may limit extrapolation of the conclusions to other subjects the volume of data collected supports the relevance and generalisability of the findings to science lessons for students aged 14 to 16 years of age (around 500,000 students each year in England, (Ofqual, 2016)).

The context of this study, and my position within it, has been important throughout the research. Although this has the benefit that I have a deep understanding of the social world being studied (Blaikie, 2007), it must be acknowledged that my interpretation of this social world is influenced by my constructed understandings of the situations through which data were collected (Crotty, 1998).

Questionnaire

As discussed in Section 4.5, aspects of the design of Student Questionnaire 1: Section 3 and Student Questionnaire 2: Section 1, may have limited their effectiveness in distinguishing between a student's Situational Interest and their Individual Interest. Some of the statements were similar, for example, 'Science is fun' and 'Science lessons are fun', with the first used as part of the assessment of Individual Interest and the second contributing to the Situational Interest score for a student. Students may not have differentiated between these two statements as evidenced by 63% of students giving the same response for each statement. This may be a result of students not being aware of experiencing science outside of a school science lesson or having their responses strongly shaped by the context within which they were completing the questionnaire. Alternatively, this might be a valid representation of their feelings towards science and science lessons as these are likely to impact each other; if a student finds science lessons fun they are more likely to consider science to be fun, and vice versa. In order to address this in the future the items intended to measure Situational Interest should be written in such a way as to make them specific to a number of learning episodes, and administered as soon after these episodes as possible to improve the accuracy of students' recall of the events and how they felt during them. These items could also be expanded to include aspects of how the students felt regards the challenge, novelty and engagement of the activities (Chen and Darst, 2002). Alternatively, this section of the questionnaire could be split into distinct halves, assessing Situational Interest and Individual Interest separately. This would allow for a small amount of preamble to explain the context of the statements. However, there are drawbacks to this as students may not read instructions beyond a couple of sentences. Further development of the questionnaire could be informed by utilising a factor analysis, with oblique rotation, on the data from Student Questionnaire: Section 3. This would provide further information as to whether this section was able to assess student levels of both Situational and Individual Interest or if these statements do not fall into two distinct categories.

The responses to Sections 1 and 2 of the Student Questionnaire 1 and to the Teacher Questionnaire suggest that the items included in the sections hold a reasonable level of validity. In addition, there were no novel suggestions provided at the end of these sections when participants were asked if there were any other things that they considered could increase interest or be the purpose of learning science. Therefore, the items included in the questionnaire covered the conscious beliefs held by students and teachers. However, it did become apparent from lesson observations that teachers act to fulfil an additional purpose, that of teaching the students to behave in an appropriate manner and act safely when working in a school laboratory, and therefore items which focus on this should be included in any future iterations of the questionnaire.

The factor analyses, using varimax rotation (see Sections 4.2 and 4.3) provided some insight into the component factors regarding Interest and Purpose; however, an analysis with oblique rotation followed by the use of Cronbach alpha analysis of internal consistency might have provided clearer results. In using varimax rotation, a method of orthogonal rotation, it was assumed that the factors are unrelated and that the analysis would produce interpretable clusters of factors as it loads a smaller number of variables on each factor. Oblique rotation methods allow for correlation within the factors which may be likely given the nature of the variables being assessed. It may be reasonable to assume that there may be a correlation between students' responses to the variables such as 'Feeling I know what I should be doing' and 'If I feel I have control over my work'. Therefore, the use of an oblique rotation method might well reveal a more appropriate correlated factor structure (Field, 2013) and this should be explored if the questionnaire is to be developed in the future.

Qualitative data collection methods (Stage 2)

Students' conscious and considered responses to surveys do not always reflect their reactions and behaviours in lessons. Therefore, an advantage of Stage 2 of the method was that it allowed triangulation of the quantitative data.

Stage 2 of the study could potentially be criticised for not specifying a number of the teaching strategies for the teachers to trial with their classes. However, both the teachers involved and I believe that the most successful teaching strategies are those which are in tune with a teacher's personal teaching style and thus wanted to try individual adjustments to our own teaching based upon a shared understanding of the Interest and Purpose Factors generated from Stage 1.

7.4 Areas for further research

Many students across all ability sets will go on to further study or work that has a scientific component; however, lower ability students are more ambivalent about there being any *Professional relevance* or, in fact, any purpose to their GCSE studies. It would be very worthwhile to gain further insight into the students' views on this since significant numbers of these students from School A, and it can be presumed the other schools too, enter industries such as farming, hair and beauty, and health and social care, all of which rely on underlying scientific principles. As discussed above, if self-determination theory is correct it should be possible to increase student interest though emphasis on the Purpose Factors, through providing external motivators for students. Given the relationship that *Personal relevance* has with the Interest Factors it would be worth investigating if similar patterns of interest levels and agreement with the Interest Factors are found for students studying either vocational courses or context-based courses which are designed to emphasise the personal relevance aspects of learning science rather than being predominantly content driven. Unfortunately, since 2014 courses which are considered vocational, or applied, no longer count towards schools' performance data in league tables which has led to a number of schools dropping these courses and therefore limiting the scope for investigating their impact based upon the findings of this study.

The current study found differences between the views of teachers and the views of the majority of students with regards to both Interest and Purpose Factors. This is not a surprising conclusion as a number of studies have reported similar mismatches of opinion (for example, see Appleton and Lawrenz, 2011). It is therefore imperative that further research is carried out to identify key gaps in understanding and, more importantly, effective classroom strategies and pedagogical techniques to enable teachers, and students, to narrow these gaps in order to support the development of interest and increase learning.

The data presented in this thesis suggest that there is a strong relationship between interest, self-efficacy and student knowledge and that these three aspects may interact to influence a student's attainment and progress through school. It is clear that there is a strong correlation between a student's interest level and which ability set they are placed in; thus, there would appear to be a correlation between interest level and attainment. However, further research is required to assess the cause and directionality of this relationship. It would be useful to know if the same relationship between interest and attainment is apparent in other subjects studied at GCSE level; however, this may be difficult to determine for those subjects which are taken as options (i.e. not English and Mathematics) where students are often taught in mixed-ability classes. Alternatively, the fact that they are taught in mixed-ability classes may have an impact on the strength of the relationship and therefore outcomes for students. On a related point, it is interesting to note that School A has, in the past, struggled to support students in the lower ability groups to reach their target grades in their Science GCSEs (as based on FFT20 predictors), whereas the students in the higher ability sets normally achieve their target grades and there is anecdotal evidence to suggest that this pattern is reflected across numerous schools. The findings from this research strongly suggest that this may be related to the low interest and low self-efficacy levels of these students and that student progress may be improved if they are supported in increasing interest, although more evidence would need to be collected as to the underlying reasons for different levels of progress.

Similarly, it would be useful to increase our understanding of why there is a gender gap in both Situational and Individual Interest in science and what impact this has on progress. It may be possible that female students, at age 14, are more aware about the importance of gaining qualifications for future careers than their male peers. Unfortunately, despite a number of literature searches, I have not been able to find any research which supports or refutes this hypothesis. It may therefore be a potential area for further study but is outside the remit of the current study

It has been shown that Situational Interest and therefore interest in science lessons can be increased by working with a focus on using the Interest Factors, in a manner tailored for specific classes, as well as increasing the emphasis on all of the Purpose Factors. The next step in this line of enquiry would be to investigate which facets of the interventions had a positive impact on students' Situational Interest, potentially through a series of structured investigations using an action research methodology. This would have the potential to explore whether or not the factors can be classified into a hierarchy, in the same way as Maslow's (1943) hierarchy of needs from his theory of human motivation, to guide teachers on how best to structure the integration of the Interest Factors.

In summary, it is possible to increase a student's interest in science lessons through adjustments to teaching practice. These adjustments should focus on providing students with the opportunity to learn from others, for example, with well-managed group work, and mediate the level of challenge students face, which can be done by effective use of puzzles and both physical and theoretical modelling. In addition, teachers and students should engage in discussions on the wide range of reasons for studying particular content, so as to help students see such content as meaningful and relevant. Teacher-student relationships are key to increasing students' interest levels. Positive relationships, based on mutual respect, provide a setting for autonomy-supportive teaching and allow for effective communication where students are receptive to teacher feedback. Evidence suggests that such adjustments to teaching should also lead to an increase in self-efficacy. Teachers can enhance their teaching through frequent reflective practice that takes into account not only their own judgements but also student responses, both verbal and behavioural, thus creating a climate in which learning is a shared experience with joint responsibility between teachers and students. The effectiveness of this reflective practice among teachers can be enhanced through the formation of critical friendships with colleagues. If teachers engage with the three facets of critical friendships, reflective practice and teaching focused on interest and self-efficacy, they, and their students, should make cognitive and affective gains with regards to science education.

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Appendices

Appendix 1: Student Questionnaire 1

I am currently undertaking research into student and teacher perceptions of interest in GCSE science lessons and would appreciate your support by completing the following questionnaire. This survey contains questions about you and your attitudes about learning science in school and consists of four sections. I am asking for your name as I would like to ask some students to complete a further questionnaire at a later date to see how your views may change over time. You do not have to complete any or all of the sections or questions.

Please seal your questionnaire with the sticky label provided before handing it back to your teacher. This will help to ensure that your responses are kept confidential. Your teachers and others at your school will not see your responses.

This is not a test so please feel free to ask your teacher for help if you do not understand a statement, but do not discuss it with your friends as I am interested in your own views.

If you need any further information or wish to discuss the study in more detail please do not hesitate to contact me.

Thank you for your assistance.

Mrs H Darlington

Name	*(capital letters)*
Gender	Male / Female *(please delete as appropriate)*
Date of Birth	*(DD/MM/YYYY)*
School	
Form Group	
Science group	

Section 1: Things which might make science lessons interesting

How interesting do you find each of the following activities or opportunities?

Please place a tick in only one of the boxes on each row to indicate how interesting you do, or think you would, find each of the following:

	Activity / Opportunity Statement	1: Not inter est-ing	2	3	4	5: Very inter es-ting
1	Being able to discuss the topic with my teacher					
2	Being able to discuss the topic with the rest of the class					
3	Being able to pick the topic I will study					
4	Being able to present the information in a way I choose					
5	Being given responsibility for my work and learning					
6	Carrying out practical work					
7	Developing a better understanding of scientific concepts					
8	Developing an understanding of the links between topics					
9	Doing drama to model scientific ideas					
10	Doing drawings which show scientific ideas					
11	Doing logic puzzles					
12	Doing mind teasers					
13	Doing something instead of the teacher just talking					
14	Doing tasks which will help me prepare for examinations					
15	Doing things which are related to my future career					
16	Doing well in tests or assignments					
17	Feeling I know what I should be doing					
18	Having the opportunity to carry out independent studies					
19	Having the opportunity to explore the unknown					
20	Having the opportunity to solve problems					

21	If I already know something about the lesson topic					
22	If I am given challenge					
23	If I am supported in making good choices					
24	If I can see the link between the activities and the learning objectives					
25	If I can see the link between the resources and the learning objectives					
26	If I can see the links between new information and something I have previously learnt					
27	If I can see the science we're learning is important in life					
28	If I feel I have control over my work					
29	If I have a sense of achievement					
30	If I have to think about the ideas					
31	If I know something about the area of science we are studying					
32	If I learn strange facts					
33	If it helps me understand how the world works					
34	If the teacher is interested in the lesson					
35	If there is feedback on the choices I have made					
36	Learning information which is relevant to me					
37	Learning the information in different ways					
38	Making models to help explain scientific ideas					
39	Using computers in our class					
40	Using models to explain difficult theories					
41	Watching the teacher demonstrate an experiment					
42	Watching videos					
43	When I can choose who to work with					
44	When the teacher is knowledgeable					
45	Working in small groups					

Are there any activities, apart from the ones above, which make you more interested in science lessons?

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Section 2: Why do you learn science in school?
To what extent do you agree with the following statements about the reasons why you learn science in school? *Please tick only one box on each row.*

	Statement	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
1	To teach me things which will be useful for a job					
2	To give me confidence when making decisions					
3	To help me make decisions about scientific issues					
4	To teach me how to use different types of scientific equipment					
5	To help me understand current environmental issues					
6	To interest me and make school enjoyable					
7	To learn about different scientists					
8	To learn how scientists investigate the world					
9	To explain how scientific investigations are done					
10	To learn scientific facts					
11	To make me more interested in science					
12	To learn some scientific theories					
13	To prepare me for my future career					
14	To prepare me to get a GCSE in science					
15	To teach me about how to be healthy					
16	To teach me how to interpret scientific data					
17	To train people to be scientists					
18	To understand what science has achieved					

19	We all learn science because the country needs scientists					
20	To develop ideas about how the world works					
21	To get a GCSE qualification					
22	As the knowledge and skills are important in life					
23	To help me to get a job or go on to further education					
24	So people do not take for granted what has been achieved					
25	Because it is just so interesting					

Are there any other reasons for studying science in school? ___________

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Section 3: How interested are you in learning school science?
To what extent do you agree with the following statements? *Please tick only one box on each row.*

	Statement	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
1	Compared to other subjects, I feel relaxed studying science					
2	Compared to other subjects, science is exciting to me					
3	Everyone should learn science					
4	I am more interested if I put more effort into the lesson					
5	Science is boring					
6	I can apply what we are learning in our science classes to real life					
7	I can see how what I learn from science applies to life					
8	I cannot see why some people devote their lives to the study of science					
9	I dislike science lessons					
10	I don't find anything interesting about science lessons this year					

11	I enjoy finding out about science for myself					
12	I enjoy studying science					
13	I have always enjoyed studying science at school					
14	I look forward to science lessons					
15	Science lessons are fun					
16	Science is fun					
17	I would be glad to do something science based for my work experience					
18	I think the field of science is interesting					
19	I think what we are studying in science class is useful to know					
20	Investigating scientific ideas which are already understood is a waste of time					
21	My other lessons are more interesting than science					
22	I am not really interested in using science in my future career					
23	Science is enjoyable					
24	I plan on taking more science courses even when I don't have to					
25	Science lessons bore me					
26	Someday I want to have a job that involves science					
27	Teachers should make the lessons interesting					
28	To be honest, I just don't find science interesting					

Section 4: Final Questions
This section contains questions about your science courses and your future plans.

1) Which science course are you studying in Years 10 and 11? E.g. type of course, exam board

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2) What are you planning to do after you complete Year 11?

- ❑ Continue at school
- ❑ Go to college
- ❑ Start an apprenticeship
- ❑ Start a job

Please provide further details *(e.g. what subjects are you thinking of taking)*:

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3) Do you think your Year 10 and 11 science course will help you with your future plans?

- ❑ A lot
- ❑ A little bit
- ❑ Not at all

Please give the reasons for your answer:

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4) Do you think you should be given the choice of whether or not to study science in Years 10 and 11?

- ❑ Yes
- ❑ No

Please give the reasons for your answer:

End of Questions. Thank you for your time! Mrs H Darlington

Appendix 2: Teacher Questionnaire

I am currently undertaking research into student and teacher perceptions of interest in GCSE science lessons and would appreciate your support by completing the following questionnaire. This survey contains questions about you and your beliefs about student attitudes towards learning science in school and consists of four sections. I am asking for your name as I would like to ask some teachers to complete a further questionnaire at a later date to see how your views may change over time. You do not have to complete any or all of the sections or questions.

Please seal your questionnaire with the sticky label provided before handing it back to the person co-ordinating data collection at your school. This will help to ensure that your responses are kept confidential. Your students and others at your school will not see your responses.

If you need any further information or wish to discuss the study in more detail please do not hesitate to contact me.

Thank you for your assistance.

Mrs H Darlington

Name	*(capital letters)*
Gender	Male / Female *(please delete as appropriate)*
Date of Birth	*(DD/MM/YYYY)*
School	
Form Group	
Science group	

Section 1: Things which might make science lessons interesting

How interesting do you think your students find each of the following activities or opportunities?

Please place a tick in only one of the boxes on each row to indicate how interesting your students do, or would, find each of the following:

	Activity / Opportunity Statement	1: Not interest-ing	2	3	4	5: Very interes-ting
1	Being able to discuss the topic with my teacher					
2	Being able to discuss the topic with the rest of the class					
3	Being able to pick the topic I will study					
4	Being able to present the information in a way I choose					
5	Being given responsibility for my work and learning					
6	Carrying out practical work					
7	Developing a better understanding of scientific concepts					
8	Developing an understanding of the links between topics					
9	Doing drama to model scientific ideas					
10	Doing drawings which show scientific ideas					
11	Doing logic puzzles					
12	Doing mind teasers					
13	Doing something instead of the teacher just talking					
14	Doing tasks which will help me prepare for examinations					
15	Doing things which are related to my future career					
16	Doing well in tests or assignments					
17	Feeling I know what I should be doing					
18	Having the opportunity to carry out independent studies					
19	Having the opportunity to explore the unknown					
20	Having the opportunity to solve problems					

21	If I already know something about the lesson topic					
22	If I am given challenge					
23	If I am supported in making good choices					
24	If I can see the link between the activities and the learning objectives					
25	If I can see the link between the resources and the learning objectives					
26	If I can see the links between new information and something I have previously learnt					
27	If I can see the science we're learning is important in life					
28	If I feel I have control over my work					
29	If I have a sense of achievement					
30	If I have to think about the ideas					
31	If I know something about the area of science we are studying					
32	If I learn strange facts					
33	If it helps me understand how the world works					
34	If the teacher is interested in the lesson					
35	If there is feedback on the choices I have made					
36	Learning information which is relevant to me					
37	Learning the information in different ways					
38	Making models to help explain scientific ideas					
39	Using computers in our class					
40	Using models to explain difficult theories					
41	Watching the teacher demonstrate an experiment					
42	Watching videos					
43	When I can choose who to work with					
44	When the teacher is knowledgeable					
45	Working in small groups					

Are there any activities, apart from the ones above, which make your students more interested in science lessons?

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Section 2: Why do students learn science in school?
To what extent do you think that students may agree with the following statements about the reasons why they learn science, particularly at Key Stage 4, in school? *Please tick only one box on each row.*

	Statement	Stro ngly disa gree	Disa gree	Neut ral	Agre e	Stro ngly agre e
1	To teach me things which will be useful for a job					
2	To give me confidence when making decisions					
3	To help me make decisions about scientific issues					
4	To teach me how to use different types of scientific equipment					
5	To help me understand current environmental issues					
6	To interest me and make school enjoyable					
7	To learn about different scientists					
8	To learn how scientists investigate the world					
9	To explain how scientific investigations are done					
10	To learn scientific facts					
11	To make me more interested in science					
12	To learn some scientific theories					
13	To prepare me for my future career					
14	To prepare me to get a GCSE in science					
15	To teach me about how to be healthy					
16	To teach me how to interpret scientific data					
17	To train people to be scientists					

18	To understand what science has achieved					
19	We all learn science because the country needs scientists					
20	To develop ideas about how the world works					
21	To get a GCSE qualification					
22	As the knowledge and skills are important in life					
23	To help me to get a job or go on to further education					
24	So people do not take for granted what has been achieved					
25	Because it is just so interesting					

Are there any other reasons students may cite for studying science in school?

End of Questions

Thank you for your time!

Mrs H Darlington

Appendix 3: Responses to the question "Are there any activities, apart from the ones above, which make you more interested in science lessons?"

These statements were student responses to the Pilot 2 survey (Figure 3.3, Step 8) completed by 103 students. The numbers next to each statement refer to the participant number which was assigned to each completed survey (1 to 103) on a random basis. All statements have been corrected for spelling but are otherwise as they appeared. A number of these responses informed the modification of the questionnaire to produce Student Questionnaire 1.

5. Daresbury science lectures / open days / science museums
8. working in pairs with a friend – helps you learn better
17. drawings help me learn about science
21. just practical lessons
22. working with dangerous or strange chemicals that give interesting results
23. being able to discuss the work with others and feeling comfortable with the people you are surrounded by during each lesson
25. being able to discuss the work with others in the lesson and being able to choose who you work with in groups so that you feel more comfortable speaking about ideas in class
30. our physics teacher shows a limited knowledge. I feel that I have learned nothing as we do the same thing each lesson
31. watching videos that are relevant
32. sitting with people that you get on with
33. sitting with people you get on with and know because if I am sat near people who I don't get on with it is intimidating, I find it quite difficult
34. when you get to do an experiment
35. doing experiments

37. more practicals, demonstrations; more group challenges
40. do more experiments
44. lots of practicals
45. doing the experiments ourselves
50. do more experiments & watch videos/programmes
56. if the teacher is fully interested in teaching the lesson and giving us a good education, which sometimes appears to be a frustration to the teacher
57. practicals / the teacher actually knowing the answer
58. the teacher not just making us watch a video which is usually irrelevant to what we're doing and her not just reading from the textbook and if she actually knew what she was 'teaching'.
77. watching videos which explain science in an interesting way
79. applying science to life. Definitely practical work
81. doing experiments or activities in large or small groups
84. Bigger and better experiments
88. doing as many experiments, practicals and investigations as possible
92. more practicals, learning less about stuff we don't need / won't help us
93. making an explosion
94. when the teacher explains things properly so there is not a problem during applied tasks, though some teachers are not brilliant at this
95. making models and completing creative projects that can help me understand the way things work
96. having a good teacher that explains things clearly, making / drawing something to help me understand
97. doing work outside, experimenting on nature etc
98. when the teacher explains everything so we all know what to do
99. being able to work with who I want too in small groups
103. outdoor activities

Appendix 4: Responses to the question "Are there any other reasons for studying science in school?"

These statements were student responses to the Pilot 2 survey (Figure 3.3, Step 8) completed by 103 students. The numbers next to each statement refer to the participant number which was assigned to each completed survey (1 to 103) on a random basis. All statements have been corrected for spelling but are otherwise as they appeared. A number of these responses informed the modification of the questionnaire to produce Student Questionnaire 1.

1. Main GSCE / good for future jobs
7. as you need good results for your GCSE's in maths, science and English in order to get a good job when you are older
21. to help us through life
22. to get GCSEs for college and university
24. so I can get a GCSE and give me more options in the future
25. if it is something interesting to pupils and they want to learn what science careers they can pursue
31. so we know why stuff happens
32. to help get the best test results in science
33. to help achieve the best results
34. to help us get jobs
35. to help when we go for jobs and in the future
38. to get good grades too get into university
40. it is a crucial part of life
41. so I can achieve my future goal, a university course in computer science
44. so one can become a scientist
59. because this is a school of science and science creates and makes the world go
74. it helps people not to take for granted what we have achieved

79. it is just so interesting

81. because it will help people in their future careers

84. to learn things we might need to know for our career

93. to develop ideas about how the world works

94. to develop ideas of how the world works

Appendix 5: Self-observation Lesson Planning form

Lesson teacher:	Class:	Date:	Focus for observation: Student Interest	Check	Evidence
Objectives (long term/lesson):			**Outcomes:**	Factors developing interest	Personal Endeavour; Exploring Science; Puzzles; Control; Learning from Others; Modelling
				Purpose of the lesson	Developing knowledge; Professional Relevance; Personal Relevance; Social Relevance
Lesson outline:				Build on prior learning / Challenging tasks / Pace	
			Resources:	Teacher expertise Effective use of feedback, questioning/ Dialogue	
				Variety of T&L strategies Pupil confidence / enthusiasm / independence	
				Differentiation SEND Role of TA(s)	
			Homework/extension activities:	Assess progress (peer, self, teacher) Mini plenaries	
				Literacy (reading, speaking & listening, marking policy)	

Appendix 6: Lesson Observation Record Sheet

Observed Teacher: Observer:
Class: Date:

Focus of Observation: Student Interest

Criteria	Evidence – from observation
Factors developing interest: Personal endeavour; Exploring science; Puzzles; Control; Learning from others; Modelling (carried over from Stage 1 of my research)	
Purpose of the lesson: Developing knowledge; Professional relevance; Personal relevance; Social relevance (carried over from Stage 1 of my research)	
Methods employed by the teacher and other adults enthuse, engage and motivate pupils and engender high levels of enthusiasm, enjoyment and commitment to learning.	
Pupil behaviours which indicate interest in the lesson	

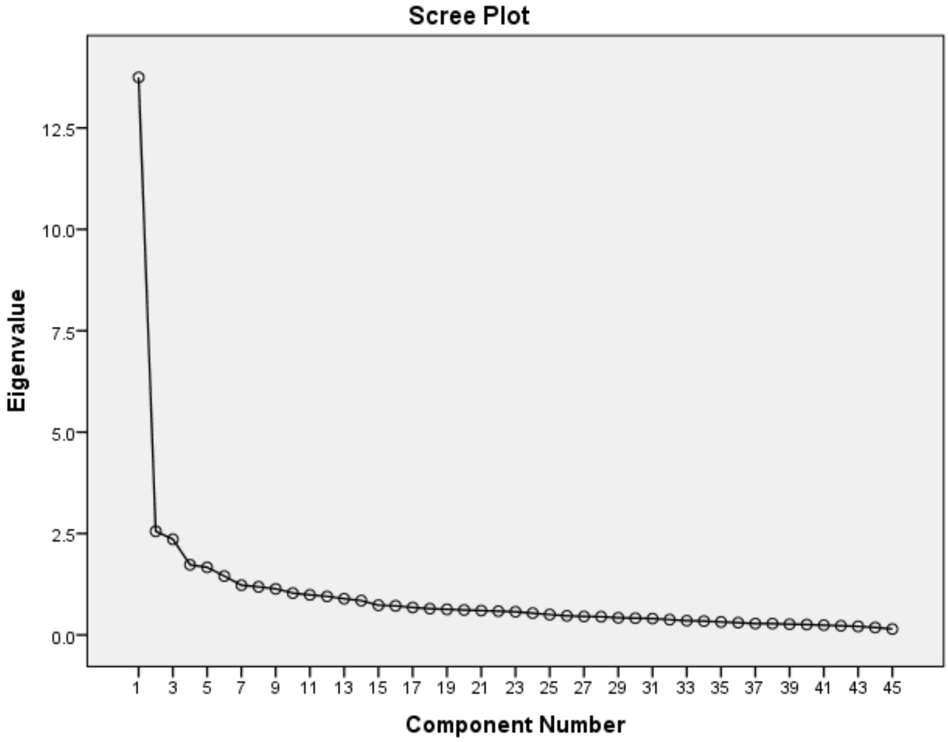
Appendix 7: Factor analysis results for Interest Factors

The table and scree plot are the SPSS Statisitcs output of a factor analysis, with varimax rotation and Kaiser Normalization. Eigenvalues equal to or greater than 1.00 were extracted. With regard to the 45 items used, orthogonal rotation of the items yielded six factors, accounting for 16.4%, 9.5%, 6.9%, 6.8%, 6.5% and 6.0% of the total variance respectively, a total of 52.3% of the total variance explained.

Rotated Component Matrix[a]						
	Component					
	1	2	3	4	5	6
1.36	.698	.098	.010	.111	.181	.139
1.35	.654	.302	-.003	.093	.173	.048
1.31	.634	.203	.029	.248	.044	.126
1.37	.623	.017	.176	-.019	.087	.269
1.29	.623	.179	-.001	.238	.332	.108
1.28	.623	.179	.055	.364	.096	-.008
1.33	.594	.370	.008	.056	.141	.054
1.27	.585	.288	-.019	.113	.164	.077
1.18	.571	.019	.296	.351	-.005	-.002
1.30	.546	.261	.282	.200	.031	.022
1.26	.540	.453	.128	.121	-.028	.089
1.19	.528	.020	.370	.161	.040	.071
1.32	.512	.145	.020	.155	.289	.242
1.34	.498	.404	.031	-.112	.358	.060
1.23	.464	.368	.107	.362	.178	.080
1.21	.430	.336	.319	.101	.057	-.040
1.13	.367	-.261	.258	.226	.176	.184
1.1	.235	.747	.018	.118	.098	.048
1.7	.266	.644	.254	.247	.051	.043
1.8	.206	.615	.404	.126	-.069	.083
1.25	.472	.516	.184	.066	-.073	.195
1.24	.450	.513	.192	.071	-.119	.160
1.41	.144	.470	.167	-.103	.377	.228
1.2	.143	.451	-.047	.222	.239	.305
1.14	.275	.345	.303	.243	.186	-.281
1.12	-.027	.132	.813	-.066	.122	.153
1.11	.011	.100	.785	-.024	.131	.257
1.20	.376	.207	.638	.165	.059	.000
1.22	.337	.265	.445	.240	.088	.061
1.3	.129	.014	-.012	.643	.120	.221
1.4	.177	.227	.062	.606	-.034	.305
1.17	.457	.205	.085	.516	.224	-.148
1.15	.374	.017	.161	.493	.305	-.163
1.5	.322	.283	.064	.484	-.079	.160
1.42	.026	.018	.060	-.162	.643	.090
1.45	.072	.039	.097	.206	.590	.159

1.43	.181	.007	-.063	.303	.566	.090
1.44	.341	.416	.128	.083	.517	-.058
1.39	.120	-.034	.136	.070	.499	.239
1.16	.351	.204	.158	.413	.456	-.152
1.38	.295	.010	.192	.031	.174	.714
1.9	.007	.096	.049	.130	.060	.698
1.40	.329	.130	.176	-.050	.265	.612
1.6	.128	.128	.071	.308	.222	.452
1.10	-.028	.286	.288	.229	.080	.380

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.[a]
a. Rotation converged in 10 iterations.



Data for Figure 4.4 Mean strength of agreement with each Interest Factor for all students.

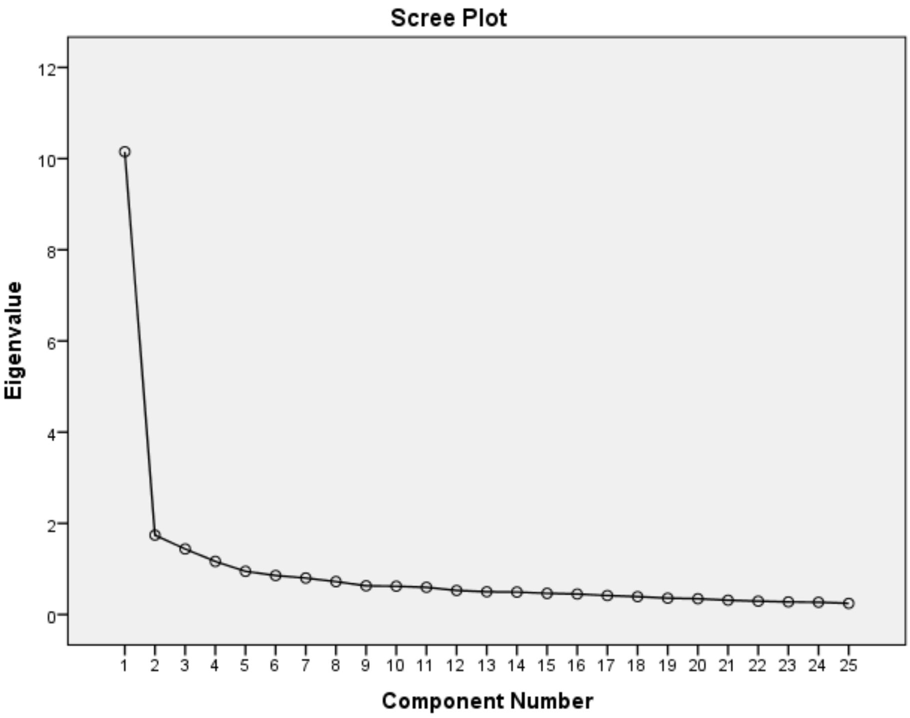
	Mean student rating	**95% confidence limits**
Learning from others	1.057	0.073
Control	0.711	0.074
Personal endeavour	0.61	0.071
Puzzles	0.354	0.088
Modelling	0.322	0.086
Exploring science	0.085	0.080

Appendix 8: Factor analysis results for Purpose Factors

The table and scree plot are the SPSS Statisitcs output of a factor analysis, with varimax rotation and Kaiser Normalization. Eigenvalues equal to or greater than 1.00 were extracted. With regard to the 25 items used, orthogonal rotation of the items yielded four factors, accounting for 19.4%, 15.8%, 11.7% and 11.1% of the total variance respectively, a total of 58.0% of the total variance explained.

Rotated Component Matrix[a]				
	Component			
	1	2	3	4
3.16	.702	.062	.204	.297
3.12	.682	.231	.086	.224
3.10	.676	.293	.148	.177
3.9	.671	.159	.292	.103
3.4	.627	.322	.171	.129
3.8	.569	.018	.496	.258
3.5	.567	.412	.075	.099
3.3	.550	.377	.354	.028
3.20	.478	.350	.132	.372
3.11	.394	.275	.382	.244
3.21	.349	.728	-.120	.085
3.23	.141	.693	.188	.317
3.13	.212	.676	.332	.124
3.14	.525	.626	.034	.012
3.1	.171	.623	.423	.064
3.22	.200	.579	.210	.387
3.15	.379	.399	.253	.197
3.6	.189	.307	.687	.172
3.2	.149	.397	.676	.002
3.7	.374	-.124	.598	.301
3.25	.181	.084	.560	.526
3.19	.167	.114	.016	.728
3.24	.002	.307	.333	.630
3.17	.285	.060	.153	.589
3.18	.501	.214	.089	.556

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.[a]
a. Rotation converged in 17 iterations.



Data for Figure 4.6 Mean strength of agreement with each Purpose Factor for all students.

	Mean student rating	**95% confidence limits**
Professional relevance	0.783	0.067
Developing knowledge	0.542	0.061
Social relevance	0.202	0.063
Personal relevance	0.172	0.065

Appendix 9: Data tables for figures in Chapter 5

Data for Figure 5.1 Mean Situational Interest and Individual Interest scores from each of the schools.

	Mean Interest Score				95% confidence limits			
	School A	School B	School C	School D	School A	School B	School C	School D
Situational Interest	0.124	4.613	5.321	7.200	1.317	1.705	2.058	1.778
Individual Interest	1.495	2.672	4.482	5.638	1.313	1.529	2.266	1.835

Data for Figure 5.2 Mean strength of agreement with the Interest Factors from each of the schools.

	Mean student rating			
	School A	School B	School C	School D
Learning from others	0.815	1.166	1.155	1.418
Control	0.547	0.726	0.982	0.949
Personal endeavour	0.390	0.616	1.024	0.895
Puzzles	0.180	0.393	0.577	0.573
Modelling	-0.027	0.410	0.551	0.899
Exploring science	-0.221	0.200	0.393	0.423
	95% confidence limits			
	School A	School B	School C	School D
Learning from others	0.118	0.137	0.169	0.125
Control	0.122	0.135	0.178	0.157
Personal endeavour	0.114	0.127	0.165	0.133
Puzzles	0.139	0.161	0.247	0.212
Modelling	0.131	0.161	0.200	0.174
Exploring science	0.120	0.153	0.204	0.165

Data for Figure 5.3 Mean strength of agreement with the Purpose Factors from each of the schools.

	Mean student rating				95% confidence limits			
	School A	School B	School C	School D	School A	School B	School C	School D
Professional relevance	0.689	0.721	0.938	1.043	0.114	0.120	0.123	0.112
Developing knowledge	0.394	0.588	0.670	0.789	0.100	0.112	0.120	0.120
Social relevance	0.169	0.278	0.298	0.018	0.108	0.114	0.122	0.145
Personal relevance	- 0.019	0.329	0.367	0.241	0.102	0.112	0.149	0.143

Data for Figure 5.4 Student response, by School, to who has more of an influence on increasing student interest during lessons.

	Mean scores		95% confidence limits	
	Student's Responsibility	Teacher's Responsibility	Student's Responsibility	Teacher's Responsibility
School A	0.350	1.125	0.153	0.127
School B	0.791	0.874	0.159	0.174
School C	0.805	0.949	0.192	0.218
School D	1.071	1.089	0.198	0.220

Data for Figure 5.5 Student scores for Situational Interest and Individual Interest when grouped by ability, based on the ability set the student in taught in at their school.

	Mean Interest Score				95% confidence limits			
	Set 1	Set 2	Set 3	Set 4	Set 1	Set 2	Set 3	Set 4
Situational Interest	5.553	3.848	0.371	-2.510	1.296	1.497	2.023	2.805
Individual Interest	5.239	3.623	-0.652	-2.571	1.298	1.397	1.805	2.311

Data for Figure 5.6 Mean strength of agreement with the Interest Factors from students in the different ability sets across all schools.

	Mean student rating			
	Set 1	Set 2	Set 3	Set 4
Learning from others	1.168	1.113	0.918	0.720
Control	0.913	0.785	0.419	0.345
Personal endeavour	0.853	0.643	0.365	0.056
Puzzles	0.495	0.357	0.208	0.076
Modelling	0.476	0.401	0.160	-0.250
Exploring science	0.344	-0.007	-0.079	-0.404
	95% confidence limits			
	Set 1	Set 2	Set 3	Set 4
Learning from others	0.102	0.120	0.188	0.286
Control	0.108	0.125	0.176	0.235
Personal endeavour	0.094	0.120	0.174	0.239
Puzzles	0.145	0.151	0.188	0.298
Modelling	0.135	0.153	0.188	0.284
Exploring science	0.127	0.143	0.151	0.245

Data for Figure 5.7 Mean strength of agreement with the Purpose Factors from students in the different ability sets across all schools.

	Mean student rating				95% confidence limits			
	Set 1	Set 2	Set 3	Set 4	Set 1	Set 2	Set 3	Set 4
Professional relevance	1.009	0.868	0.477	0.172	0.082	0.108	0.159	0.220
Developing knowledge	0.695	0.664	0.359	-0.071	0.080	0.094	0.137	0.220
Social relevance	0.318	0.201	0.121	-0.116	0.088	0.114	0.143	0.229
Personal relevance	0.231	0.282	0.094	-0.186	0.098	0.114	0.137	0.208

Data for Figure 5.8 Student responses, by ability set, to who has more of an influence on increasing student interest during lessons.

	Mean scores		95% confidence limits	
	Student's Responsibility	Teacher's Responsibility	Student's Responsibility	Teacher's Responsibility
Set 1	0.750	1.016	0.131	0.133
Set 2	0.537	0.903	0.192	0.171
Set 3	0.647	1.235	0.204	0.176
Set 4	0.457	1.021	0.296	0.288

Data for Figure 5.9 Student responses, by ability set, to who has more of an influence on increasing student interest during lessons comparing students from School A with the students from the other schools.

	Mean Scores			
	School A Student's Responsibility	Other Schools Student's Responsibility	School A Teacher's Responsibility	Other Schools Teacher's Responsibility
Set 1	0.656	0.909	1.262	1.099
Set 2	0.429	0.963	1.000	0.975
Set 3	0.255	0.500	1.057	0.931
Set 4	-0.222	0.600	1.143	-0.143
	95% Confidence limits			
	School A Student's Responsibility	Other Schools Student's Responsibility	School A Teacher's Responsibility	Other Schools Teacher's Responsibility
Set 1	0.271	0.199	0.137	0.151
Set 2	0.254	0.264	0.189	0.204
Set 3	0.268	0.214	0.373	0.336
Set 4	0.505	0.448	0.436	0.434

Data for Figure 5.10 Mean scores for Situational Interest and Individual Interest for male and female students.

	Mean Interest Score		95% confidence limits	
	Male	**Female**	**Male**	**Female**
Situational Interest	4.054	2.450	1.227	1.252
Individual Interest	3.851	1.917	1.156	1.190

Data for Figure 5.11 Mean scores for Situational Interest and Individual Interest for male and female students from each of the schools in the study.

	Mean scores							
	School A		**School B**		**School C**		**School D**	
	Male students	**Female students**	**Male students**	**Female students**	**Male students**	**Female students**	**Male students**	**Female students**
Situational Interest	1.720	-1.645	8.179	6.268	7.000	4.459	4.481	5.034
Individual Interest	3.121	-0.376	7.256	4.098	3.737	4.865	3.169	2.172
	95% confidence limits							
	School A		**School B**		**School C**		**School D**	
	Male students	**Female students**	**Male students**	**Female students**	**Male students**	**Female students**	**Male students**	**Female students**
Situational Interest	1.795	1.909	2.350	2.648	3.191	2.636	2.417	2.428
Individual Interest	1.838	1.844	2.113	2.909	3.820	2.842	2.146	2.215

Data for Figure 5.12 Mean strength of agreement with the Interest Factors for male and female students.

	Mean student rating		95% confidence limits	
	Male	**Female**	**Male**	**Female**
Learning from others	0.965	1.162	0.112	0.092
Control	0.584	0.861	0.110	0.096
Personal endeavour	0.494	0.749	0.096	0.102
Puzzles	0.344	0.378	0.129	0.123
Modelling	0.193	0.464	0.122	0.135
Exploring science	0.150	0.028	0.118	0.110

Data for Figure 5.13 Mean strength of agreement with the Purpose Factors for male and female students.

	Mean student rating		**95% confidence limits**	
	Male	**Female**	**Male**	**Female**
Professional relevance	0.696	0.885	0.102	0.080
Developing knowledge	0.538	0.554	0.090	0.078
Social relevance	0.217	0.187	0.092	0.086
Personal relevance	0.206	0.141	0.096	0.086

Data for Figure 5.14 Mean strength of agreement with the Interest Factors from students and teachers.

	Mean student rating			
	All Students	All Teachers	School A Students	School A Teachers
Learning from others	1.058	0.667	0.815	0.625
Control	0.718	1.000	0.547	1.000
Personal endeavour	0.616	0.939	0.390	0.833
Puzzles	0.355	0.545	0.180	0.458
Modelling	0.323	0.636	-0.027	0.750
Exploring science	0.082	0.563	-0.221	0.609
	95% confidence limits			
	All Students	All Teachers	School A Students	School A Teachers
Learning from others	0.073	0.372	0.118	0.290
Control	0.074	0.265	0.122	0.380
Personal endeavour	0.071	0.255	0.114	0.233
Puzzles	0.088	0.372	0.139	0.341
Modelling	0.086	0.257	0.131	0.276
Exploring science	0.080	0.255	0.120	0.302

Data for Figure 5.15 Mean strength of agreement with the Purpose Factors from students and teachers.

	Mean student rating				**95% confidence limits**			
	All Student	**All Teachers**	**School A Students**	**School A Teachers**	**All Student**	**All Teachers**	**School A Students**	**School A Teachers**
Professional relevance	0.780	1.091	0.689	1.000	0.067	0.261	0.114	0.235
Developing knowledge	0.540	0.800	0.394	0.900	0.061	0.278	0.100	0.223
Social relevance	0.200	0.364	0.169	0.438	0.063	0.306	0.108	0.410
Personal relevance	0.170	0.205	-0.019	0.156	0.065	0.270	0.102	0.270

Appendix 10: Data table for Figures in Chapter 6

Data for Figure 6.2 Mean scores, and 95% confidence limits, for the strength of agreement with the Interest Factors from Class 1 and Class 2 students, in comparison to other students.

	Mean student rating			
	All Students	School A Students	Class 1	Class 2
Learning from others	1.058	0.815	0.613	1.081
Control	0.718	0.547	0.508	0.432
Personal endeavour	0.616	0.390	0.540	0.311
Puzzles	0.355	0.180	0.452	0.200
Modelling	0.323	-0.027	0.270	0.297
Exploring science	0.082	-0.221	0.129	-0.320
	95% confidence limits			
	All Students	School A Students	Class 1	Class 2
Learning from others	0.073	0.118	0.349	0.357
Control	0.074	0.122	0.355	0.337
Personal endeavour	0.071	0.114	0.316	0.300
Puzzles	0.088	0.139	0.419	0.302
Modelling	0.086	0.131	0.318	0.319
Exploring science	0.080	0.120	0.374	0.272

Data for Figure 6.3 Mean scores, and 95% confidence limits, for the strength of agreement with the Purpose Factors from Class 1 and Class 2 students, in comparison to other students.

	Mean student rating			
	All Students	School A Students	Class 1	Class 2
Professional Relevance	0.780	0.689	1.219	0.616
Developing knowledge	0.540	0.394	0.781	0.344
Social Relevance	0.200	0.169	0.679	0.170
Personal Relevance	0.170	-0.019	0.193	0.090
	95% confidence limits			
	All Students	School A Students	Class 1	Class 2
Professional Relevance	0.067	0.114	0.274	0.370
Developing knowledge	0.061	0.100	0.269	0.316
Social Relevance	0.063	0.108	0.265	0.329
Personal Relevance	0.065	0.102	0.325	0.341

Data for Figure 6.4 Mean interest scores (with 95% confidence limits) for students in Class 1 and Class 2 as measured by Student Questionnaire 1 (June 2012) and Student Questionnaire 2 (May 2014).

	Mean Interest Scores				**95% confidence limits**			
	Class 1		**Class 2**		**Class 1**		**Class 2**	
	2012	**2014**	**2012**	**2014**	**2012**	**2014**	**2012**	**2014**
Situational Interest	4.480	7.610	-0.400	4.143	4.633	1.595	3.179	3.604
Individual Interest	6.760	9.960	0.880	3.071	4.453	2.009	2.283	4.451

Data for Figure 6.5 Mean responses from students in classes 1 and 2, at the start and end of the data collection period, to whom has more of an influence on increasing student interest during lessons.

	Student's Responsibility				**Teacher's Responsibility**			
	Class 1		**Class 2**		**Class 1**		**Class 2**	
	2012	**2014**	**2012**	**2014**	**2012**	**2014**	**2012**	**2014**
Mean score	0.650	0.607	0.292	1.071	0.905	0.889	1.240	0.929
95% confidence limits	0.570	0.259	0.390	0.335	0.365	0.221	0.388	0.335