THE UNIVERSITY
of LIVERPOOL

STUDENTS' PERCEPTIONS OF PHYSICS AND BIOLOGY

Thesis submitted in accordance with the requirements of the University of Liverpool for the Degree in Philosophy by

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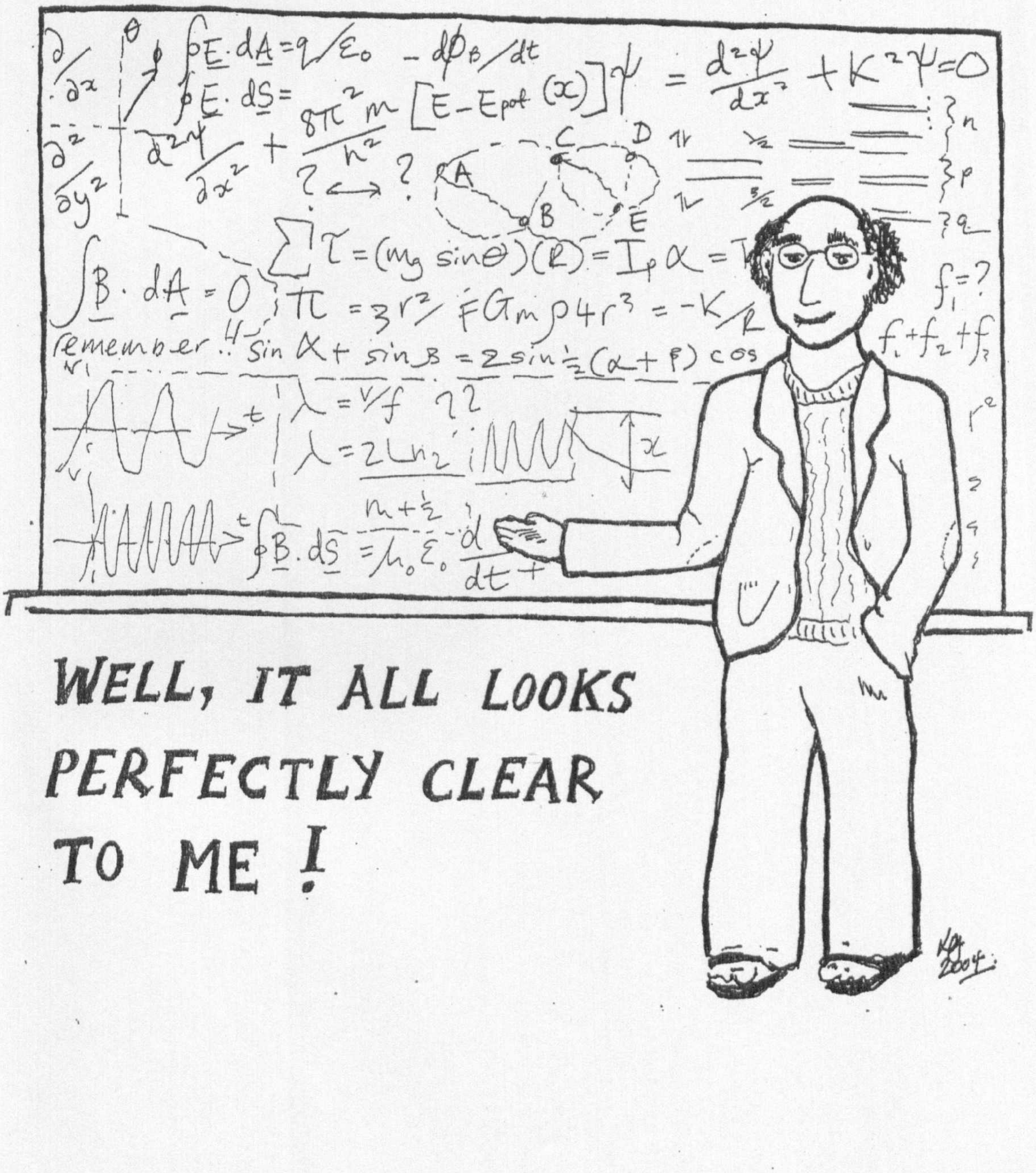
WELL, IT ALL LOOKS PERFECTLY CLEAR TO ME!

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Is that everyone?

Katie

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INTRODUCTION

Chapter One

1.1 AIMS OF THE STUDY

The Aims of the present study are:

- To examine secondary school students' attitudes to physics and biology and map how such attitudes change over the period of secondary education
- To further explore the underlying reasons for the development of these attitudes
- To identify any gender differences in students' attitudes to biology and physics across secondary and tertiary education
- To examine whether differences in biology, physics extend further into A-levels and beyond. English students who do not follow any science education will be used as an academic comparator
- To explore Biology, Physics and English students attitudes towards biology and physics in an attempt to identify what underpins students' choices to follow particular subjects at tertiary level
- To explore what teachers feel are the influential factors in developing students attitudes towards physics and biology

1.2 THE OVERALL PROBLEM

It is generally agreed that the prosperity of an industrial nation such as Britain depends upon an adequate supply of able scientists, technologists and engineers. There is a belief that the performance of the national economy is based upon a sound manufacturing base and that this, in turn, is dependent on a vigorous scientific and technological background (House of Commons, 2002). In addition, a level of scientific understanding is seen as essential for empowering citizens in an increasingly scientific and technological society (Driver, Leach, Millar and Scott, 1996).

Despite this, as a nation our perception of science and its accompanying fields are poor. Over the last few decades there has been a steady decline in the numbers of people choosing to study science (Barber, 1993; Young, 1993; Sheldrake, 1994). This means that there are fewer graduates planning careers in research and development. Figures for 2001 compared to 2000 show that 13% fewer graduates are opting for a career in the research and development areas (Curtis, 2002). The Roberts report (2002) warned of growing shortages in the supply of high-level mathematics, physics, chemistry and engineering skills in the public sector. The Roberts Review of the supply of scientists and engineers in the UK found that as well as there being a increased shortage of people entering the science fields, there is also some evidence that increasing numbers of senior scientists and engineers are leaving the UK.

In addition, there is disquiet among the teaching profession and the academic physics community that there may be a negative feedback loop that will make this problem resistant to solution. The general shortage of science graduates means that fewer scientists are also entering into the teaching profession to nurture the next generation of scientists. This will be further discussed in a later section of this chapter.

1.3 SCIENCE IN SCHOOLS

During the 1980s a move was made, both in England and in other countries, to persuade politicians that science was so central to contemporary culture that it should be a compulsory element for all school students from age 5 to 16. This process resulted in the implementation of compulsory 'science for all' in the first version of the National Curriculum (DES 1989). Science now found itself at the curriculum high table (House of Commons Science & Technology Committee 2002; Osborne and Collins 2000) alongside mathematics and English. Yet, some argued that this structural change was undertaken without any explicit consideration of the aims and values of science education (Osborne and Hennessy, 2003). In effect, it was argued, the previous model of science education that had been reasonably well suited to the minority who chose to continue with science post-14 of their own accord was imposed on all school students.

Broadly speaking, there are four arguments for the value of science education which can be found in the literature (Layton 1973; Millar 1996; Milner 1986; Thomas & Durant 1987). These are called the utilitarian argument, the economic argument, the democratic argument and the cultural argument.

1.3.1 The utilitarian argument

The utilitarian is based on the argument that learners might benefit, in a practical sense, from learning science. That is, that scientific knowledge enables them to wire a plug or fix their car, or, in more general terms, that a scientific training develops a 'scientific attitude of mind' or a practical problem-solving ability that is unique to science and essential for improving the individual's ability to cope with everyday life. However, Millar (1996) argues,

> *"there is no evidence that physicists have fewer road accidents because they understand Newton's laws of motion, or that they insulate their houses better because they understand the laws of thermodynamics"*

So, a utilitarian argument for scientific knowledge is open to challenge on a number of fronts.

1.3.2 The economist argument

From this economist perspective, school science provides a pre-professional training and acts as a 'sieve' for selecting the chosen few who will enter academic science, or follow courses of vocational training. The 'wastage' of those who study science but do not continue to study at an advanced level or obtain employment in science is justified by the fact that the majority will ultimately benefit from the material gains that the chosen few will provide. The data on the skills and proficiencies needed for the world of work, however, raises some doubts about this argument. Coles (1998) carried out an analysis of scientists and their work, and job specifications, in order to summarise the components of scientific knowledge and skills that are important for employment. Coles' data suggest that knowledge of science is only one component amongst many that are needed for the world of work. Furthermore, his data show that knowledge that professional scientists do need is quite specific to the context in which they are working. The scientists themselves stressed the importance of the skills of data analysis and interpretation, and general attributes such as the capacity to work in a team and an ability to communicate fluently, both in the written word and orally. Yet these are aspects that are currently undervalued by modern practice in science education.

1.3.3 The cultural argument

There is an argument, the cultural argument, that science is one of the great achievements of our culture – a shared heritage that forms the backdrop to the language and discourse that permeate media, conversations and daily life (Cossons 1993; Millar 1996). In a modern context, where science and technology issues increasingly feature in the popular media (Pellechia 1997), this is a strong argument. The implication of such a view is that science education should be directed more towards an appreciation of science, developing an understanding of what it means to do science, and what a hard-fought struggle and great achievement such knowledge represents. However, in the current National Curriculum, emphasis is more on factual science.

1.2.4 The democratic argument

The political and moral dilemmas posed by modern society are increasingly of a scientific nature. For instance, do we allow cloning of human beings? Should we prevent the sale of British beef? Should we allow electricity to be generated by nuclear power plants? Participation in such debate requires at least some knowledge of science and its social practices. As the European Commission (1995) has argued:

> "*Clearly this does not mean turning everyone into a scientific expert, but enabling them to fulfil an enlightened role in making choices, which affect their environment and to understand in broad terms the social implications of debates between experts.*"
>
> *(p28)*

Many would argue that public debate about socio-scientific issues would be of greater benefit if our future citizens held a more critical attitude towards science (Fuller 1998; Irwin 1995; Norris 1997). However, it is difficult to see how this can be done by a science education which, despite the inclusion of an element of 'Scientific enquiry', offers no chance to develop an understanding of how scientists work, fails to explore how it is decided that any piece of scientific research is 'good' science, and which offers a picture of science as a body of knowledge which is "*unequivocal, uncontested and unquestioned*" (Claxton 1997).

Science education in schools cannot develop only as a training ground of future science specialism. As early as in 1959 in the Crowther Report (Crowther, 1959) and in 1968 in the Dainton Report (Dainton, 1968), concern was expressed about the need to promote the study of science for people who were not to become scientists. One common theme of these reports was that people should understand the impact of science on society, and that the division between scientists and the general population should be reduced. The improvement of the scientific literacy of the whole population is now seen as a major objective of those working in the science education field. Science education can give people a sense of control over their technological environment, rather than being at its mercy.

1.3 ATTITUDES TO SCIENCE

1.3.1 Publics attitudes towards science

Public attitudes to science, engineering and technology has been heavily researched (Miller *et al*, 1997; National Science Board, 2002). It has been found that on the whole the public's attitude towards science is positive. In a report funded by the Office of Science and Technology and Wellcome Trust (2000) it was established that the uses of science were generally understood by the general public in Britain, with only one fifth of the public claiming that they are not interested in science and seeing no reason why they should be. There was also awareness amongst the public that Britain needs to develop science and technology in order to enhance its international competitiveness. However, concern was raised over the use of science and the ability of society to control science.

One of the main criticisms of looking at public attitudes is of considering 'the public' as an homogenous group. In reality, 'the public' combines any number of communities with varying needs, expectations, aspirations, attitudes and opinions. The publication, Science and the Public (2000) made a first attempt to break down respondents according to views and patterns of behaviour, but undoubtedly other approaches could be taken. Furthermore, science itself is a far from homogeneous concept, encompassing facts, uncertainties, methodologies and raising complex ethical issues.

1.3.2 Students' attitudes to science

It has been found that children have a personal definition of science even before they enter school, that is based on their worldview and built up by parents' attitudes (Osborne and Whittrock, 1983). Many of these views persist through secondary schooling regardless of their factual basis (Osborne and Whittrock, 1983). Their construction is based on beliefs, past experiences and current attitudes. Students' preconceptions about science have been found to come from teachers, the learning environment, students self-concept, peers and parental influence (Glick, 1970; Haladyna, Olsen and Shaughnessy, 1983; Jackson and Getzels, 1959; Breakwell and Robertson, 2001). These preconceptions and pre-existing attitudes will, naturally, influence students' choice of subjects.

The importance of influencing students' attitudes towards science is recognised by non-governmental bodies too. For example, the Wellcome Trust has a programme designed to engage young people.

> *"In our education work, you could say we are in the business of making science sustainable. First, we have a responsibility to ensure that our future scientists are as high quality as those that the Trust currently funds. Second, we want to ensure that tomorrow's adults are scientifically literate enough to make informed decisions about the scientific and technological advances that will affect their own lives."*
>
> (Wellcome ***Trust, 2003)***

Yet, despite these views and initiatives, a report from the UK all-party science and technology committee shows that students have become disillusioned with science because of tedious coursework and a curriculum overloaded with facts and dull experiments (Chenoweth, 2003). Writing about the situation in England and Wales, Durrani (1998) stated that

> *'The declining popularity of science is a well known fact. The number of 18 year olds taking science and maths at 'A' level fell from 42% in 1963 to just 16% in 1993'*
>
> *(Durrani, 1998)*

In order to understand why science is unpopular there has been considerable research over the last two decades exploring the attitudes of English school students to science (Young 1993; Barber 1993; Sheldrake 1994, House of Commons 2002). Such research studies have examined the attitudes towards science of various groups, from primary school children to undergraduates and the general public. In an early paper, Duckworth and Entwistle (1974) highlighted four parameters that students indicated as important in influencing their subject choices. Firstly, the subjects perceived relative difficulty, secondly, students interest or lack of in the subject, thirdly, the opportunities afforded by the subject for students to express their own ideas-freedom and finally, the perceived worthwhileness/social benefits of the subjects. Since then much of the literature has explored attitudes to science overall. For instance, many studies have explored school students' views of the science curriculum, their opinions about how science is taught, their ideas about the nature of science and their perceptions of scientists themselves. For example, some aspects of the science syllabus such as the human body and those related to 'space' are generally found interesting by students, whereas other aspects such as electric circuits are deemed boring (Osborne and Collins, 2000; Watson, 2000). In terms of the teaching process, school students appear to prefer exploratory practical work as opposed to what they see as 'copying down' (Eichinger, 1997). Although many teachers would also prefer this form of active and exploratory learning for their students (Watts and Vaz, 1997), various difficulties – pressure to complete an overcrowded curriculum, concerns about laboratory and field safety with possible litigation in the case of accident, cost of scientific equipment and consumables – work against this (Hacker and Rowe, 1997). Perhaps because of all this, school students see science as offering less freedom of expression than non-science subjects and as being more difficult (Watson, McEwen and Dawson, 1994). Finally, students tend to offer a stereotypical perception of what a practising scientist is like; male, Caucasian, white-coated, coldly objective, uninterested in people, even crazed (Hudson, 1968; Carré and

Head, 1974; Head, 1985; Hughes and Goodlad 1993; Billingsby 2000; National Science Board, 2002) – an image with which students may not wish to identify. These attitudes are subject to change. Unfortunately, however, it has been found that students' attitudes to science may become less positive from early secondary school (Cannon and Simpson,1985; Baird *et al*, 1997).

1.3.3 Differences in students' attitudes to different sciences

The main thrust of many of the studies mentioned above has been to compare students' views about science, explicitly or implicitly, with their attitudes to non-science subjects. However, this approach may mask different attitudes to subjects within science (Woolnough 1995). Thus, although strong emphasis is being placed on improving science education and the public's overall understanding and perceptions of science, the evidence suggests that students do not perceive science as an homogenous subject. However, there is much less research comparing attitudes to different areas within science.

That there is a difference in attitudes towards the different sciences is evident in the number of students electing to study the subjects at A-level. For example, the number of students sitting A-level examinations in England and Wales was 31 500 for physics compared with over 52 000 for biology (Institute of Physics 2002), suggesting that biology is considerably more popular than physics. Research has shown that among the sciences biology is generally well received. Reasons for people generally liking biology are that it deals with concrete ideas and that it is relevant to their own lives (Osborne and Collins, 2000). Physics on the other hand is not so well received; research has shown that of all the science subjects, physics is the most unpopular (Watson et al, 1994; Harvard, 1996). Osborne, Driver and Simon (1998) have suggested that physics is perceived as rather an elite subject, conceptually very difficult and more suited for the more able students. By comparing attitudes to these two sciences in more detail it may be possible to identify key areas that, if addressed might begin to alter negative attitudes towards physics.

1.3.4 The unpopularity of physics

In recent years it has become clear that physics in the UK is facing a challenge and that, if no action is taken, this could well develop into a crisis. It has been stated that the future of physics research will be endangered by the lack of well-qualified physicists (Editorial, Physics World, 1999). Some suggestions have been made to explain why physics is so unpopular. According to Rennie and Punch (1991), because of the way physics is sometimes presented, students tend to regard it as a branch of mathematics and this, in turn, is partially responsible for the attitudes of school students to physics. He went on to suggest that although the world is 'full of physics'; schools do not seem to make this obvious to students. He believed that motivation to study physics would increase if more topics relevant to everyday life were included in the curriculum.

It has also been suggested that in the physics curriculum, too many pupils are expected to pass precipitately from the concrete to hypothetical reasoning. Inadequate regard is said to be paid to differences in children's mental and emotional styles. It has been suggested that there is a need to preserve contact with reality by continued personalization of science, for example, by reference to technological evidence of applications of physics, and by appropriate conceptual analogues.

1.3.5 Gender issues

The differential uptake of science by boys and girls is apparently substantial and, with a few exceptions, it is an international problem. The past two decades have seen a great expansion in interest in the lack of involvement of girls in science, in particular the low participation of girls in the physical sciences, and their perceived failure to match the achievement of boys. Evidence of the underachievement of girls in physics is substantially supported by the data produced by the assessment and performance unit (APU) and studies such as those of Smail *et al*, 1982; Smail, 1983; Graig and Ayres, 1988; Weinburg, 1995; Ramsden, 1998; and Johnson and Murphy, 1986. These sources provide convincing evidence that boys, in general, show greater interest in science, have more positive attitudes towards it and show higher achievement. These differences usually increase with age (Johnson and Murphy, 1986). There also appears to be polarisation in success for boys in chemistry and physics but not biology (Johnson and Murphy, 1986).

The weakness of girls in physics tests had previously been reported in a number of national and international surveys. Johnson *et al* (1983) collated evidence from a number of major surveys of science performance.

In the early 1970s the International Association for the Evaluation of Educational Achievement (IEA) found that boy's performance in physics was consistently higher than girl's, in every country and at every age.

The participation of females in sciences in England has increased dramatically as a result of the move towards combined science (Her Majesty's Inspectors of Schools, 1991), at least as far as the 11 to 16 year age group are concerned. However, increased participation rates do not necessarily equate with improved performance or, for that matter, greater interest in the study of science, or a increased participation once the science subjects become optional after 16 years of age. Figures from the DfEE statistics (2001) show that the number of students opting to take physics post 16 is nearly half the number opting to take biology. The results further show that three times as many males take physics in the post 16 categories than females.

1.4 FUTURE PROBLEMS WITH PHYSICS

The problem in university physics departments across the country is that they have reduced numbers of students choosing to follow a physics degree. This situation is not confined to the UK. In a conference held by the European Physical Society 2001 it was stated that the number of physics students in Germany has fallen dramatically in the past 7 years from almost 10 000 to just over 5 000 (Skryabina 2002). The numbers of students graduating in physics in the US is also of concern (Editorial, Physics World, 1999).

Furthermore, this problem may be self-perpetuating. In addition to the decreasing number of students studying physics, it was also noted that there were alarming problems with the number of graduates becoming teachers, in both Sweden and the UK (Editorial, Physics World, 1999). The dearth of physics graduates has resulted in a shortage of secondary teachers qualified in physics. Thus in many schools teachers not formally qualified in physics teach the subject. For example, in one study it was found that two thirds of teachers who teach physics do not have a degree in the subject and that a third do not even have a physics A-level (Roberts, 2003). As a consequence, the argument goes, school students will be taught physics with less enthusiasm and 'feel' for the subject, and will be less inclined to pursue physics to advanced level.

1.5 RATIONALE

Thus, it can be seen that physics is considered important for a variety of reasons. On national level, it is important for economic reasons. On a personal level, an understanding of physics is thought by some to be important to enable individuals to participate confidently in an increasingly technological society. Millar (1996), however, disagrees with the necessity of this in enabling an individual to cope with everyday life.

A number of studies have established why students, and indeed people in general, are not attracted to science. Rather fewer studies have differentiated between attitudes to different sciences. The aim of the present study, therefore, is to examine in more detail why students have negative attitudes to physics, and to map how these attitudes may change over the period of secondary schooling and tertiary education

Chapter Two

2.1 THEORIES OF ATTITUDES

In general terms learning is the process whereby an organism changes its behaviour as a result of experience. The idea that learning is a process implies that learning takes time. In terms of human learning, the change in behaviour is likely to be accompanied by the development of certain attitudes. Stimuli take on a meaning and relationships are established between stimuli and responses; needs and the urge to satisfy them are a primary source of motivation. In addition the interests, values and attitudes towards activities influence human courses of action (Gage and Berliner 1991).

Because of their importance attitudes have long been the subject of investigation by social psychologists. In 1935, Allport wrote that the concept of attitude is "the most distinctive and indispensable in contemporary social psychology"; this phrase still makes sense today (Skryabina, 2000). Since then numerous research studies, both experimental and theoretical, have been undertaken to investigate and explain the nature of attitudes; ways they form, are stored, are retrieved, can change and the ways they influence behaviour. In part, this interest in attitudes arose because of the presumed ability of attitudes to direct and predict behaviour. The three main functions that attitudes serve can be defined as the following (Reid, 1978);

- Attitudes allow the individual to make sense of themselves
- Attitudes allow the individual to make sense of the world around them
- Attitudes allow the individual to make sense of their social interactions

In other words, attitudes allow the individual to make sense of their entire world, and influence how they appreciate the world round them and build social interactions; attitudes help individuals to know what to expect from each other. Knowing attitudes "*presumably helps others to predict the kind of behaviour we are likely to engage in more accurately than almost anything else we can tell them*" (Petty and Cacioppo, 1981, p8).

2.2 DEFINITION OF ATTITUDE

The definition of attitude has a long and complex history. In 1929 Thurstone, one of the first who investigated the problems of attitude measurement, described an attitude as "*the affect for or against the psychological object*". Although not particularly precise, this definition is still in use today, for example in the science education field (Germann, 1988). Later, Allport (1935) proposed that attitude was a "*mental and neural state of readiness to respond, organised through experience, exerting a directive and or dynamic influence on behaviour*". This definition, however, does not distinguish attitudes from other mental states such as interest or other tendencies or dispositions.

More recently, the Encyclopaedia of Psychology (2004) states that:

> *"an attitude is a predisposition to respond cognitively, emotionally, or behaviourally to a particular object, person, or situation in a particular way".*

This follows a definition given by Shaw and White (1968) that:

> *"attitude is viewed as a set of affective reasons towards the attitude object, derived from concepts and beliefs that the individual has concerning the object and predispositioning the individual to behave in a certain manner towards the object".*

An attitude object itself can be everything that becomes an object of thought. This can be an abstract object like freedom, it can be a type of behaviour (such as doing an experiment) or it can be a concrete object or person (such as a physics teacher) (Hogg and Vaughan, 1998).

All of the definitions above have been summarised by Oppenheim (1992) in a way that leads to the modern definition of attitude that would be "acceptable to most researchers" (Ramsden, 1998):

> *"attitudes [are].... A state of readiness or predisposition to respond in a certain manner when confronted with certain stimuli... attitudes are reinforced by beliefs (the cognitive component), often attract strong feelings (the emotional component) which may lead to particular behavioural intents (the action tendency component)*
>
> (Oppenheim, 1992)

An important feature of attitude is that it involves an evaluation by the individual. This feature was stressed for the first time by Rhine (1958) who considered an attitude as a *"concept with evaluative dimension"* and gave rise to the definition formulated by Chaiken and Eagly (1993):

> *"Attitude is a psychological tendency that is expressed by evaluating a certain entity with some degree of favour or disfavour"*
>
> (Chaiken and Eagly, 1993).

Thus, a person who has certain knowledge about an object will not have an attitude towards it until the evaluative response about this object has occurred. The evaluation of an attitude object can be done on the cognitive, affective or behavioural basis or a mixture of these.

2.3 ATTITUDE FORMATION BY EVALUATION

Pratkanis and Greenwald (1989) developed a socio-cognitive model of the idea of a central process of evaluation. In this, they define an attitude as a person's evaluation of an object of thought. They state that the attitude object is represented in memory by:

- An object label and the rules of applying that label
- An evaluative summary of that object
- A knowledge structure supporting that evaluation

Thus, evaluation plays a key role in attitude formation. This evaluation can take different forms (Zanna and Rempe, 1980):

- Behavioural processes (consistency with prior behaviour)
- Cognition (knowledge, thinking)
- Affect (feelings, emotions, mood)

These different forms will now be discussed in further detail in the following sections.

2.3.1 Attitude formation by behavioural processes

Many of the attitudes people hold are the products of direct experience with attitude objects. People encounter an attitude object and have a positive or negative experience, which at least partly shapes their attitudes towards that object. Furthermore, this process can become self-reinforcing as behavioural forming of attitudes takes place when the evaluation about an object builds on the basis of past behaviour (Bem, 1972). Thus, people tend to make evaluations that are consistent with their prior behaviour. For example, a student's decision to elect to continue study of a particular subject (such as physics) is based on having a positive attitude towards physics. The attitude will be formed on the basis of pupils' positive past experience, such as having done well in the subject previously. Fishbein and Ajzen (1975) have proposed that direct experience can affect attitudes towards an object by providing people with information about the attributes of a particular attitude object. According to the expectancy-value model for attitude structure, this information leads to beliefs that will influence how much people like or dislike the attitude object. Direct experiences that are especially negative or even traumatic make certain beliefs more powerful that others. For example, if a student's physics practical experiments have been stressful the student may conclude that physics practicals are unpleasant.

2.3.2 Attitude formation by cognitive process

Some researchers prefer to think of attitude formation in terms of cognitive development. The cognitive theories allow us to view attitude acquisition as "*an elaborative exercise of building connections between more and more elements, such as beliefs*" (Hogg and Vaughan, 1998). A cognitive process takes place when people obtain any information about an attitude object, and then form beliefs; it thus depends on either direct or indirect experience. Beliefs can be defined as "*associations or linkages that people establish between the attitude objects and their various attributes*" (Fishbein and Ajzen, 1975). Direct experience implies a person's direct involvement with an attitude object. For example, if physics lessons are considered as attitude objects then the students attending lessons form beliefs about physics through their direct experience. On the other hand, indirect experience implies that a person gains information about an attitude object through different sources without engaging in direct relationship with an attitude object. In the present context a student could obtain information about physics lessons from his friends, siblings or parents and form beliefs about the subject without any direct engagement with it. It has been shown that beliefs can be formed under the influence of different external factors such as television programmes, literature, parents and older peers, and that these beliefs can be very strong (Newton and Newton, 1992).

2.3.3 Attitude formation by affective processes

The forming of an attitude can also take place by affective processes when the attitude object is paired with a stimulus that can be either positive or negative. The person evaluates the object on the basis of feelings towards it. For example, it is likely that if a student finds physics classes interesting and enjoyable, likes the teacher and enjoys the lessons that they will evaluate physics itself, positively.

All three processes, behavioural, cognitive and affective, should be taken into account when considering how attitudes are being formed (although it is not necessary that all of them must be present at the point of an attitude formation). The three elements may, therefore, be involved in the formation of attitudes towards physics: physics may be perceived as an important, fascinating and challenging subject (cognitive element); the lessons may be seen as interesting, enjoyable and the teacher as good (emotional element) and engaging in physics classes is construed as a satisfying experience (behavioural element).

2.3.4 Summary of attitude formation

The cognitive component concerns a person's beliefs; the affective component involves feelings and evaluations; and the behavioural component consists of ways of acting toward the attitude object. The cognitive aspects of attitude are generally measured by surveys, interviews, and other reporting methods; the affective components are more readily assessed by monitoring physiological signs such as heart rate. Behaviour, on the other hand, may be assessed by direct observation (Gale, 2001).

2.4 MANIFESTATION OF ATTITUDES

The responses that reveal people's attitudes can be divided into categories. These categories include cognitive responses, affective responses and behavioural response. It is however unlikely that there is an exact relationship between the way an attitude is formed and the way that it is expressed (Eagly and Chaiken, 1993).

2.4.1 Manifestation of attitudes by cognitive processes

People manifest beliefs about the attitude object when they form attitudes towards an attitude object in the cognitive way. Beliefs connect an attitude object with its different attributes that can be evaluated. If physics, as a subject, is considered as an attitude object, it may be associated in the minds of students with cognitive beliefs like

- Physics is too mathematical,
- Physics is too abstract,
- Physics involves problem solving
- Physics uses a difficult language.

Evaluation of beliefs associated with an attitude object can be carried out using a scale of extremely positive to extremely negative. In general, people who evaluate an attitude object favourably are more likely to associate it with positive attributes and less likely with negative attribute, whereas people who evaluate an attitude object unfavourably are more likely to associate it with negative attributes and less likely with positive attributes. People who like physics will be likely to say that it is very good to develop problem solving skills, learn how to apply mathematics, learn to use a more complex language and learn abstract things.

2.4.2 Manifestation of attitudes by affective processes

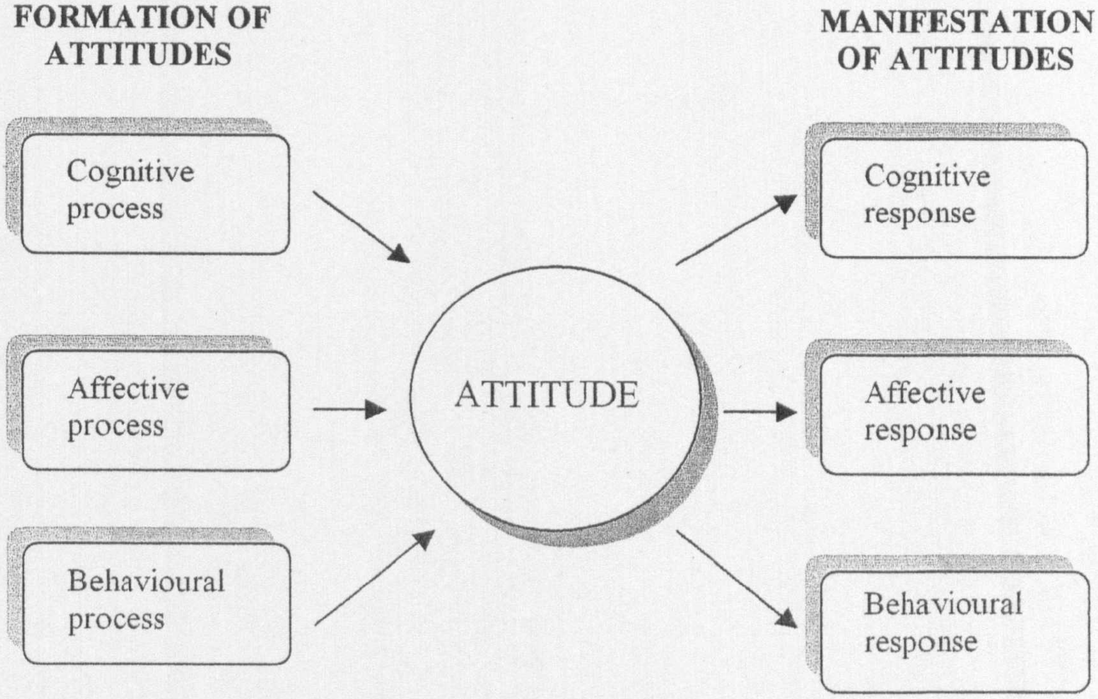
Attitudes may be manifested in feelings or emotions that people have about an attitude object. Like the cognitive method it too can range from very positive to very negative and so therefore have an evaluative meaning. "*People who evaluate an attitude object favourably are likely to experience positive affective reactions with it*" according to Eagly and Chaiken, (1993). The opposite of this occurs if unfavourable evaluation of an attitude object occurs. Example of an affective way in terms of responses to physics lessons are " I like physics lessons because the lessons are interesting, the teacher is good, and physics is fun".

2.4.3 Manifestation of attitudes by behavioural processes

Attitudes may be manifested by behaviour as a consequence of a person's overt actions with respect to the attitude object. Again these responses may range from extremely positive to extremely negative. They can also be located in the evaluative dimension of meaning too. Behavioural intentions can also be considered as types of behavioural responses, although they are not necessarily expressed in overt behaviour. In the context of science, observation of a student in the class may reveal what kind of attitude towards the subject they hold. Indeed, this can sometimes be the best demonstration of their attitudes (Skryabina, 2000).

In summary, then, attitudes can be formed by cognitive, affective and behavioural processes and then manifested through cognitive, affective and behavioural responses (Figure 2.2).

Figure 2.2 The methods of attitude formation and manifestation (Chaiken and Eagly, 1993)



2.5 ATTITUDE CHANGE

There are two mechanisms by which attitudes may be changed. In the internal dimension, attitude is changed mainly due to an individual's motivation and desire. In contrast, is the external dimension. Here, attitude is changed mainly due to external pressure, which may take the form of new information. This latter type of attitude change is not always in the control of the individual.

The education process involves some element of both of these two mechanisms. It is hard to distinguish between the two. It is impossible to keep totally out of contact with the world around us because we interact with different information, norms, rules etc. Some of these factors will play a part in changing attitudes, whilst some will have no effect at all. An understanding of the processes of attitude change is important in the design and delivery of some intervention programmes in education intended to bring about a positive influence on pupils' attitudes towards the various sciences.

2.5.1 Internal mechanisms of attitude change

The dissonance theory, developed by Leon Festinger (1957) is an influential theory that attempts to explain attitude change in terms of an internal dimension. His theories are concerned with the relationships among cognitions (pieces of knowledge).

The elements of knowledge called cognitions are compiled to form a person's attitude. These large numbers of cognitions are interconnected with each other and organised into a cognitive system. According to the cognitive consistency theories (Festinger, 1957) people strive for coherence and meaning in their cognitions. It argues that if people have several beliefs or values that are inconsistent with one another then they strive to make them consistent. Similarly, if cognitions are already consistent and faced with new cognitions that might produce inconsistencies, a person strives to minimize that inconsistency.

Leon Festinger's (1957) theory of cognitive dissonance addresses inconsistencies in behaviour and attitudes. It is based on the idea that people prefer their cognitions, or beliefs, to be consistent with each other and with their own behaviour. Dissonance is a psychological state arising when new contradictory information disrupts the existing equilibrium amongst elements of the cognitive system, leading to internal inconsistencies. Festinger stressed the importance of dissonance and described it

> " *as essentially a motivational state that energises and directs behaviour... Just as hunger is motivating, cognitive dissonance is motivating. Cognitive dissonance will give rise to activity orientated towards reducing or eliminating the dissonance. Successful reduction of dissonance is rewarded in the same sense that eating when one is hungry is rewarding*"
>
> (Festinger, 1957, p.70)

Dissonance creates psychological tension and as such is an uncomfortable state. That is why, in order to reduce inconsistencies, a new, or change in, attitude may occur. Dissonance may be reduced by:

- Changing the existing elements of knowledge to make the earlier cognitive system, and newly obtained knowledge, consistent. This may lead to changes in both attitude and behaviour.
- Finding and accepting, the consistent elements from the source of dissonance. This will lead to reducing dissonance, but does not, in general, lead to attitude change.
- Denying the importance of the new cognition. Attitude is not changed, but earlier attitude becomes even stronger (Simon, Greenburg and Brehm 1995).

Thus, the cognitive consistency theories show that having inconsistencies tends to lead to instability. This instability can be observed through overt behaviour.

Attitude change can be considered as one of the outcomes of reducing this instability.

Whatever the method adopted for reducing the dissonance, the resulting attitude leads to greater internal mental consistency. By going through the process of experiencing the dissonance, feeling uncomfortable with the previous held attitude and trying to restore the balance, the person will readjust the cognitions adopting an attitude that will make them feel stable and comfortable again and the attitude will be one in which they will be able to defend.

Of all the approaches of reducing dissonance previously mentioned, the first is considered to be the most difficult. This is because people normally find it difficult to change their existing beliefs, attitudes and behavioural elements.

If a person in a school setting, for example, was forced to take a subject which they did not like they may find that over time the lesson was interesting, or that they got on well with the teacher. The real lesson does not match what the person had believed about the lessons and this may lead to dissonance. To try and restore this dissonance the person may change the attitude towards the subject to a more favourable one, which may result in changes in the student's behaviour towards this subject. However, it may be that the student finds it more beneficial to continue to keep the previous attitude. If this occurred then it would be extremely difficult to change the attitude of the student and the end result would be a greater consistency towards the first attitude. This may then be shown in the overt behaviour of the student, in this case the behaviour in the lesson may deteriorate.

2.5.2 External Mechanisms of Attitude Change

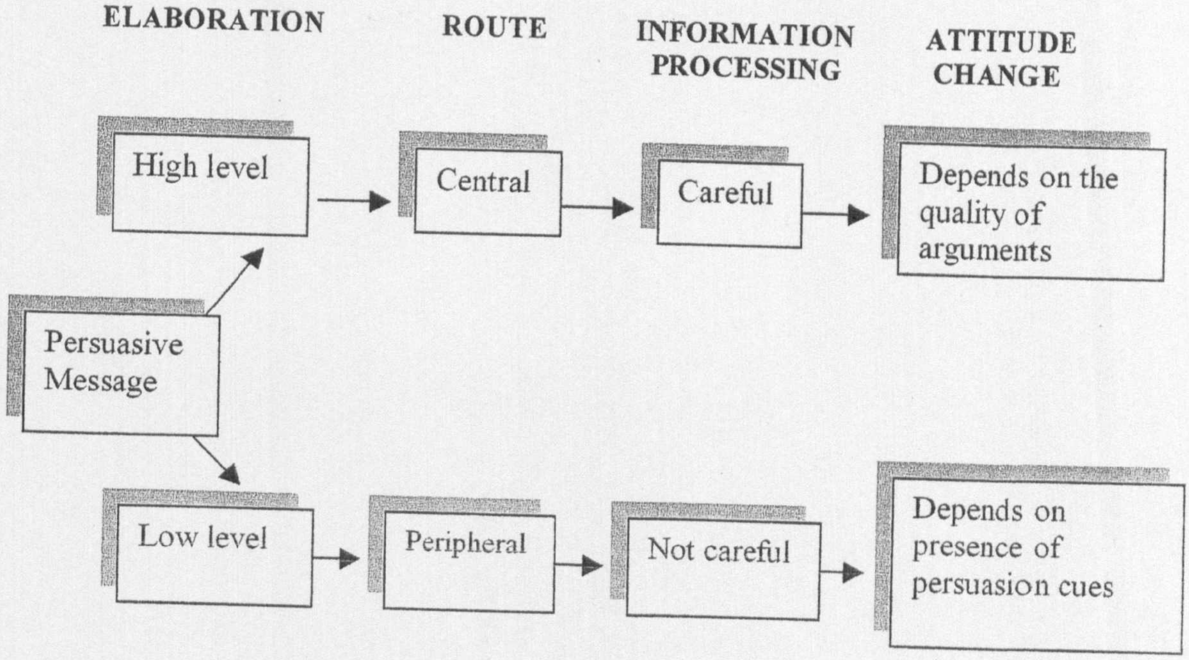
Persuasion and its role in attitude change were pioneered by Carl Hovland and his colleagues (Hovland *et al,* 1953). They proposed that the key to understanding why people would attend to, understand, remember and accept a persuasive message was to study the characteristics of the person presenting the message, the contents of the message, and the characteristics of the receiver of the message. They asked " *Who says what to whom and with what effect?*" (Hogg and Vaughn, 1998).

Much research has since followed this work addressing questions such as "If a person was exposed to a certain kind of information, how would this influence their attitude?" "Why does attitude change occur with a persuasive message in some cases and not others?" "Are changes that occur as a result of the persuasive message permanent, or can a person revert back to the old attitude?" "How do changes in attitude influence a person's behaviour?"

Although the persuasive models that have been developed by Petty and Cacioppo (Petty and Cacioppo 1986; Petty et al 1994, Petty and Wagner 1998) and Chaiken (Bohner et al 1995; Chaiken 1980, 1987; Chaiken et al 1998; Eagly and Chaiken 1993) take different approaches, there are elements in common. Each model postulates two processes.

Petty and Cacioppo's model of attitude change was named the 'Elaboration Likelihood Model' (Petty and Cacioppo, 1981) which proposes that, when people receive a persuasive message they think about the arguments it makes, though not necessarily deeply or carefully. This is because it requires a lot of cognitive effort, which is only likely to be put in if the issue is recognised, by the individual, as being important. They believe that persuasion follows one of two processes, and the one selected depends upon the amount of elaboration required. If the arguments of the message are closely followed then the *central route* is used. We learn the arguments in a message and extract the point that meets our needs and even indulge mentally in counter arguments if we disagree with some of them. If this process is to be used then the points in the message need to be convincing because it requires cognitive effort. The personal motivation to process the message is playing an important role in this process (Petty, Ostrom and Brock, 1981). On the other hand, when arguments are not well attended to, a peripheral route is followed. This route does not involve any active thinking about the attributes of the issue or object under consideration. By using peripheral cues, the individual acts on a superficial basis. Attitude, therefore, can be changed purely as a result of the influence of emotions or impressions. This route to attitude change can be considered as "intellectually cheap". The alternative routes available according to this model can be seen in Figure 2.3.

Figure 2.3 The elaboration-likelihood model of persuasion



Central route processing

Some models from the central route focus on how the arguments in a persuasive message are comprehended and learnt: One such approach is called the message learning approach (Hovland, 1953). This looks at how different variables affect a person's attention to the persuasive message. They stated that for a message to be processed then the message should be attended to, understood and comprehended (Hovland et al, 1957).

One of the main persuasion processes identified by many of the models, is that rationalising is an important process. The personal relevance, interest, motivation, benefit should be switched on to process the message. The individual attending to the message arguments will attempt to understand them, comprehend and then evaluate them. The Dissonance model previously mentioned can be used to explain how the persuasive message evaluated can lead to cognitive dissonance and possibly attitude change.

Peripheral Route Processing

Through the peripheral route attitude change can be brought about through such things as reward and punishment and background of the communicator. These factors will be looked at in more detail.

Reward and punishment

Classical conditioning of attitude change or associative learning is an example of such an approach. People like objects and recommendations that previously have been paired with unconditioned stimuli that generate positive affective responses and dislike objects and recommendations that previously have been paired with unconditional stimuli that generate negative affective responses. For example, an unpleasant experience in a physics laboratory can develop a negative attitude towards physics classes.

Operant conditioning is another example of associative learning. It is based on the idea that people try to maximise positive consequences of their behaviour. In other words behaviours associated with positive consequences increase in strength and frequency. For example students like the course, at least in part because of the reward that they receive in the course. Achievement can generate positive attitudes towards the subject studied. Both forms of conditioning emphasise the role of direct reinforcers in the acquisition and maintenance of behaviour in general.

The Communicator

People tend to adopt the position of an expert, since it is likely to lead to reward (Triandis 1971). It has been shown that there are a group of variables relating to characteristics of the source, which can have significant effects on the acceptability of a message to an audience (Hogg and Vaughan, 1998). A good level of expertise, good physical appearance and extensive interpersonal and verbal skills will make a communicator more effective at persuasion. For example, students may adopt the point of view of the teacher because they are the experts and this may lead to positive consequences like getting a good mark.

Others view attitude formation as a social learning process, one that does not depend on direct reinforcers. Bandura (1973) studied social learning and concentrated on modelling, whereby one's behaviour is modelled on another's. Modelling is learning by observation. Individuals learn new responses by observing the outcomes of others responses. Having friends who dislike science, for instance, is likely to influence a person's opinion about science. In these cases the person is quite often not able to correctly show any factual knowledge regarding this decision or define why they dislike it (Hogg and Vaughan, 1998).

It has also been reported that the relevance of the message can lead to differences in the strength of the attitudes. For example it has been shown that if the persuasive message is personally relevant to the person then it can bring about stronger attitudes in comparison to when it is not personally relevant (Petty and Cacioppo, 1981).

The schematic depiction of the processes taking place using the central and peripheral routes can be seen in the Figure 2.4 taken from the work of Petty and Cacioppo (1986, p126). It represents the way an attitude can be changed using either of these routes and the things needed to proceed each way.

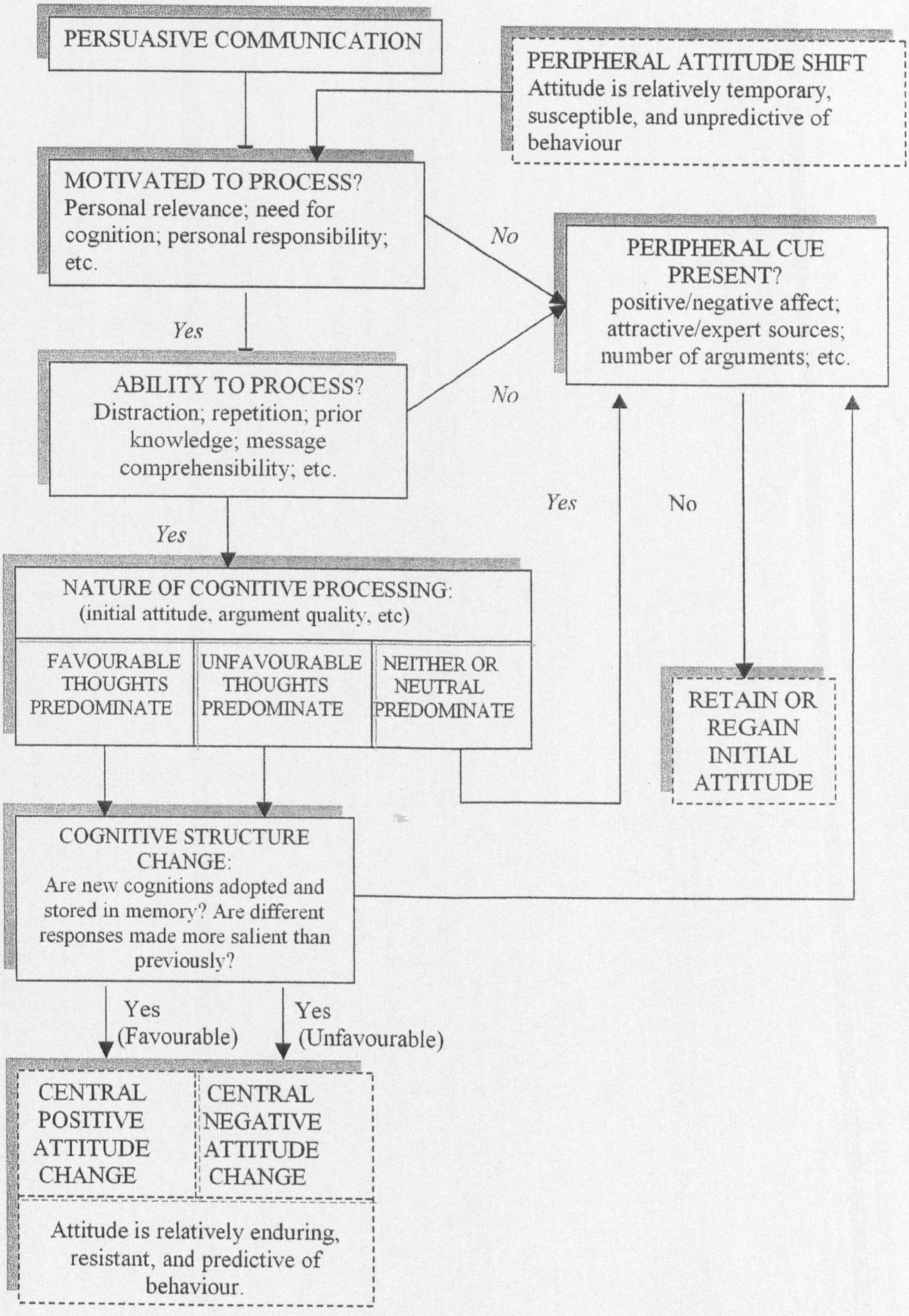
Persuasion is a powerful tool for attitude change and control in education.

2.6 ATTITUDE MEASUREMENT

In this research the definition of attitude proposed by Chaiken and Eagly (1993) was used. This emphasises the evaluative element of attitude. On the basis of this, the research will seek to explore the kind of attitudes people have towards physics and the way these attitudes develop.

An attitude is a private event that is externally unobservable and whose existence we can only infer (Hogg and Vaugan, 1998). As highlighted by these authors, this presents one of the biggest problems of investigating attitudes. Their latent construct nature cannot be directly measured, but only constructed from observed responses taking place under certain observed stimuli connected to an attitude object.

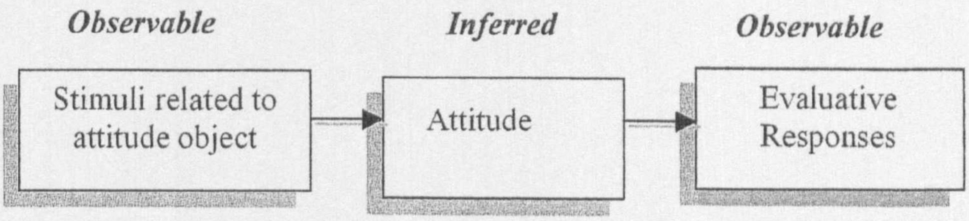
Figure 2.4 Central and Peripheral Routes of Attitude Change



Attitude can be considered as one of the numerous mental states that explain why people react in certain ways when confronted with certain stimuli. Thus, responses observed under certain stimuli can be connected to a certain kind of mental state (mood, interest, attitude, habit).

A general picture of attitude investigation can be represented as " *an inferred state that accounts for co-variation between stimuli denoting attitude object and evaluative responses to these stimuli"(*Skryabina, 2002). This is represented graphically in Figure 2.5

Figure 2.5 Graphical Representation of Inference of Attitude from Observable Stimuli and Responses.



To gain insight into a person's attitude, therefore, we can only construct from the observable evaluative responses. An individual's evaluation brings about a tendency to respond to the attitude object either positively or negatively. Initially this attitude may last for a short time. However, when this response to the attitude object is repeated the attitude may become established. Once established, an attitude will be stored in long-term memory and can be activated under the presence of an attitude object or cues related to it.

METHODOLOGY

Chapter Three

3.1 INTRODUCTION

As established in the previous chapter a person's knowledge and beliefs affect their behaviour and so influence their attitudes. To gain some insight into these attitudes it is necessary to measure what people think. However, measuring an attitude is not an easy task; since attitudes cannot be observed directly; they must be measured indirectly. This chapter surveys the various methods available for probing people's ideas. There is no ideal, universal method, so it is necessary to identify the strengths and weaknesses of the different research approaches.

3.2 METHODS OF PROBING IDEAS

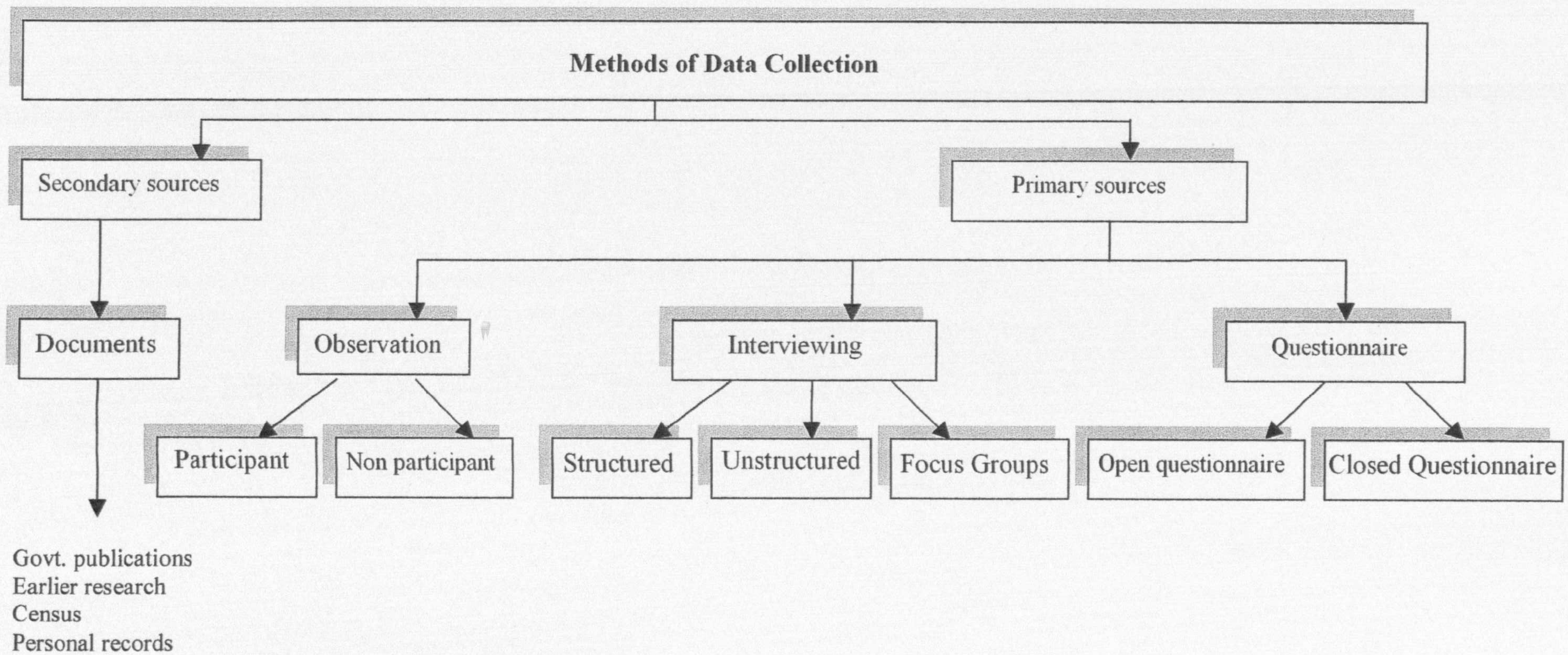
Cook and Seltiz (1964) categorized the techniques of attitude measurement into five types and their analyses have stood the test of time:

- self report (e.g. questionnaire)
- observation of overt behaviour
- partially structured stimuli
- performance of tasks (congenial material learned rapidly)
- physiological tests

These five types of attitude measurements can be considered under two broad types of approaches – the direct approach and the indirect approach. Direct methods are those that involve direct contact with the person by means of questionnaires or interviews, or both. These methods are self-reporting methods whereby the person provides a report of their attitude. They include individual interviews or group interviews; the latter sometimes includes focus groups. Indirect methods are those in which the researcher does not inform the subject of their presence. It does not involve the subject directly in the research; their attitude is extracted from the set of indirect investigations (observations).

There are different methods and techniques available to collect information via these means but, since no one of them is perfect, Cook and Selltiz, (1964) have stated it is dangerous to rely on just one of these techniques, although indirect methods can be a useful tool. However, such approaches are cumbersome and can involve considerable amounts of time. Also, there is a potential for misinterpreting the final results. For these reasons, direct methods are therefore more commonly used. More specifically, research in the science education field is commonly based on direct methods, such as questionnaires and interviews.

Figure 3.1: Methods of data collection



3.3 DIRECT METHODS

3.3.1 Questionnaires

> " *The questionnaire is an important instrument of research, a tool for data collection...it can be considered as a set of questions arranged in a certain order and constructed according specially selected rules. The questionnaire has a job to do: its function is measurement".*
>
> (Oppenheim, 1992, p 100)

A questionnaire can be based around the use of open or closed items. The closed items are those that offer the respondent a number of fixed responses. Whereas open items are those that give the respondent an opportunity to write whatever they feel is the appropriate answer. However, both of these types of items have some advantages and disadvantages; these are explained below.

Advantages of questionnaires

A questionnaire gives all respondents an equal opportunity to answer a set of questions, usually anonymously and without interference from or direct influence of the researcher because of the limited contact with the respondent. The other advantages of using questionnaires are that they are familiar to most people. At some time or another everyone has had some experience of completing questionnaires and they generally do not make people apprehensive. The responses are gathered in a standardised way, so questionnaires are more objective, certainly more so than interviews (Milne,1999). A questionnaire is usually short and focussed and so it is an efficient way of obtaining information.

Disadvantages of questionnaires

Despite the many advantages there are still drawbacks to using questionnaires. One of the main problems with questionnaires is that they are standardised, so it is not possible to explain any points in the questions that participants might misinterpret. In addition to this point, questionnaires rely on respondents' cognitive understanding, as there is little chance for clarification during the completion of the questionnaire.

During the design process factors such as the length, level and depth of information of the questionnaire are of the utmost importance. If the questionnaire is too long then there is a tendency for respondents to answer superficially; if it is too short essential information may be lost (StatPac, 2002).

The level of the questionnaire must be appropriate for the respondent group. For example, a questionnaire designed for a target audience of adults will not be suitable for children. In some cases questionnaires are simply not suitable; for example, for a group of respondents with limited reading skills.

In some cases the types of information required from respondents presents problems with questionnaires. Respondents may not be willing to answer the questions. They might not wish to reveal the information or they might think that they will not benefit from responding or perhaps even be penalised for giving their real opinion. Leading on from this point is the fact that with questionnaires there is an inability to probe responses. In this respect questionnaires are not the most suitable of methods to use, in comparison to interviews.

Response rates may vary with questionnaires. This response rate depends upon a number of factors; the interest of the potential respondents in the topic under study; the layout and length of the questionnaire; the quality of the letter explaining the purpose of the study. In some cases the response rate may be very low (e.g. 20%). Low response rates, however, cause a number of problems with the most obvious being that potential data is not gained. However, even if sufficient responses are gained for analysis, there may be sample bias due to self-selection. Those who return their questionnaires may have opinions or attitudes that are different from those who do not. Problems of low response rates can however, be overcome by administering the questionnaire in a collective situation (Kumar, 1999).

Finally, another drawback of questionnaires is that they allow little flexibility to the respondents with respect to response format. Fixed choice questions may not have an appropriate alternative to meet the respondents' attitudes.

3.3.2 Open Questionnaires

Advantages of open questionnaires

An open question does not contain any kind of fixed possible responses where the respondents must select a choice. Instead it allows the respondents the chance to provide their own answers in their own words to a question. The open questionnaire offers the opportunity to gather a range of respondents' ideas and gives them a chance to explain their answers. Based on this it can also be used as an informing tool for the design of a closed instrument or to explore the reasoning underlying answers to closed questionnaires.

The advantages to an open questionnaire item are that it allows people to express an opinion, view or experience in their own words. It enables the collection of information, which an individual knows, or attitudes they hold, and so can indicate the strength of their feelings on a particular topic. In addition, information collected can be comprehensive. It is thought to be a better tool in some instances than interviews because they relieve the stress that interviews can sometime cause. Another advantage of this method is that it allows the collection of data from a larger number of people than is generally possible when using a quasi-experimental or experimental design.

The open questionnaire item is easy to ask and its "*chief advantage is the freedom it gives to the respondent*"(Oppenheim, 1992, p 112). An example of an open form questionnaire item as used in the present study can be seen in Figure 3.2.

Disadvantages

However, there are some drawbacks to using open form questionnaire items. Unlike most approaches that involve direct observation of behaviour, questionnaires rely on individuals' self reports of their knowledge, attitudes or behaviours. In these circumstances the validity of the information is contingent on the honesty of the respondents.

Figure 3.2 Example of open-form questionnaire item

> Please write down a list of things you like about biology. Please write as much as you can
>
> •
>
> •
>
> •
>
> •

In addition to this there can be problems with the understanding of questions. It is not possible to clarify unclear or seemingly ambiguous questions. Interviews have the advantage of allowing gestures and other visual cues to be noted; this is not available with written questionnaires. In a similar way there is personal contact in interviews, which is absent with an open questionnaire. This can have different effects depending on the type of information being requested. Further problems come with open questionnaires when the responses need to be coded or reduced to a manageable set; this usually means being able to condense them into a small number of categories. This is both time consuming and raises problems of reliability; in the coding of free responses consistency is important. This is less of a problem with a single researcher, although even here there is a danger of criteria changing as a lengthy set of responses is analysed. If multiple researchers are involved consistency between them is achieved at the cost of multiple standardisation meetings. Robson (1993) states, *"The desire to use open-ended questions appears to be almost universal in novice researchers, but is usually rapidly extinguished with experience".*

However, it is important that the content of closed questionnaire is grounded, at least in part, in respondent's own ideas. Given this, open questionnaires are useful in designing the content of subsequent closed questionnaires.

3.3.3 Closed questionnaires

The closed questionnaire is a quantitative approach to gathering and summarising information about responses. There are two widely recognised methods of measuring attitudes using a closed form questionnaire: one designed by Thurstone, a social psychologist, who first created attitude-measurement methodology in 1928 (Hogg and Vaughn, 1998), the other by Likert in 1932. Thurstone scales are still one of the main ways to measure attitude (Mueller, 1986). Thurstone's method involves defining and identifying the object, then making a pool of opinion statements, some positive, some negative, some neutral.

One of the practical drawbacks of the Thurstone scale is that its construction is tedious and time consuming. To cope with this, Likert (1932) developed a different technique. He stressed that when trying to measure attitude for something, it is easier to measure for tangible objects than for abstract objects. Likert believed in constructing multiple scales, or narrowly defining scales, so that other dimensions would not be included.

Figure 3.3 Scale value of items related to 11-point Thurstone equal-intervals scale

THURSTONE SCALE
Attitude towards Contraception

How favourable	Value on 11 point scale	Item
Least	1.3	practising contraception should be punished by law
	3.6	contraception is morally wrong in spite of possible benefits
Neutral	5.4	contraception has both advantages and disadvantages
	7.6	contraception is a legitimate health measure
	9.6	contraception is the only solution to many of our social problems
Most	10.3	We should not only allow but enforce limitations on family size

(Hogg andVaughan,1998)

He generated a pool of items that included statements about beliefs for the object in question. Each item was clearly positive or negative; unlike Thurstone, Likert did not use neutral statements. So, in contrast to the Thurstone scale, a person's attitude is measured by asking them to indicate the extent of agreement or disagreement with each item. Each statement has an evaluative response scale usually consisting of five positions, running from strongly agree, through neutral, to strongly disagree. The Likert scale has the advantage that it is open to the application of statistical analysis (Hogg and Vaughan, 1998).

Osgood, devised the Semantic Differential (SD) method of measuring attitudes. It is an attitude scale that was designed to measures people's reactions to stimulus words and concepts in terms of ratings on bipolar scales defined with contrasting adjectives at each end.

An example of an SD scale is:

Good __ __ __ __ __ __ __ Bad
3 2 1 0 1 2 3

Unlike the Likert, this technique usually provides a total of seven points rather than five, and the points in between the extremes are not labelled. The subject is therefore forced to provide his own rating on a 'one to seven' scale only knowing the description of the two extremes. However, a major disadvantage to this method is that different respondents may interpret the scale differently.

Disadvantages of closed questionnaires

Despite their many advantages, which will be discussed later, there are some disadvantages. One of the main disadvantages of closed questions is that the information obtained through them lacks depth and variety. There is a greater possibility of investigator bias because the researcher may list only the response patterns that they are interested in or those that come to mind. To over come this, a closed questionnaire should have an option to neither agree or disagree with the item. Finally another drawback of closed questionnaires are that they allow little flexibility to the respondent with respect to response format. Fixed choice questions may not include an appropriate response

Advantages of closed questionnaires

The use of questionnaires with closed items are popular in research because they allow for the collection of data quickly, cheaply and easily. The use of closed ended questions provides ready-made categories within which respondents reply to the questions asked by the researcher. This helps to ensure that the information needed by the researcher is obtained. With large respondent groups the results can be generalised. In addition to this, one of the main advantages of the use of closed questionnaires is that they allow for statistical analyses of the responses because the possible responses are already categorised. Because of these advantages, closed questionnaires were used in many components of this present study.

3.3.4 Combined open and closed questionnaires

The decision to use a combined method of open and closed questionnaires depends upon the purpose of the information, the type of study population and the method proposed for communicating the findings. The use of this method potentially provides the advantages of both open and closed questionnaires.

Disadvantages of open and closed questionnaires

As with all open questionnaire methods, they can be time consuming for both the respondent filling them in and the researcher analysing them.

Advantages of open and closed questionnaire

Using a combination of the two questionnaire methods allows the quantitative collection of data whilst allowing people to express an opinion, view or experience in own words

3.3.5 Interviews

Interviews are a commonly used method of collecting information from people. They are a method of collecting data verbally through direct interaction between a researcher and a respondent or group of respondents. In interviews the researcher leads and guides the discussion. Interviews are classified according to the degree of flexibility they have. They can be unstructured or structured.

Unstructured interviews are when the interviewer develops a framework or guide within which to conduct the interview. The interviewer then will formulate questions spontaneously during an interview. This technique is useful when little is known about an area or when in depth information is needed. There is a lot of flexibility allowed to the interviewer in what they ask which can elicit rich information (Kumar, 1999).

Structured interviews involve the investigator asking pre-determined questions, using the same wording and order of questions as specified in the interview schedule. This is normally a list of questions, open or closed. They are designed for use in a person-to-person interaction (this could be face to face, by telephone or by other electronic media).

Disadvantages of interviews

One of the main concerns with interviewing is that the researcher may introduce their bias in the way they frame the questions and interpret responses. The data that is obtained by these techniques is also very dependent on the interaction between the interviewer and interviewee. Interviewing can also be a time-consuming and expensive technique, particularly when respondents are scattered over various geographical areas.

Advantages of interviews

Interviews have certain advantages over questionnaires. They have the advantage of allowing for the collection of in-depth information, have a higher response rate and can use a variety of people (Polit and Hungier, 1991). The use of an interviewer can also help clear up any ambiguous questions that can occur when using questionnaires.

3.3.6 Focus Groups

Focus groups, in essence, are group interviews that rely, not on a question and answer format of interview but on the interaction within the group (Morgan, 1988). The reliance on interaction between participants is designed to elicit more of the participants' points of view (than would be evidenced in a more researcher dominated interviewing).

Using focus groups is appropriate when the interest lies in how individuals form a schema or perspective of a problem. They are often used to test new approaches and discover concerns. The focus group's interaction allows the process of a struggle for understanding how others interpret key terms and their agreement or disagreements with the issues raised (Mertens, 1997). A focus group capitalises on communication between participants (Kitzinger, 1995).

When using focus groups, systematic variation within groups is the key. Examples include composing groups that vary on different dimensions such as age, ethnicity or gender.

Disadvantages of focus groups

Despite the many advantages of focus groups, there are, as with many of these techniques, a few disadvantages. The sample is small and may not be representative of the population in general. In addition to this the group dynamics may have a negative influence on some in the group. For example a more articulate individual may silence a more introverted individual.

The analysing of the data from focus groups can be cumbersome and complex, as it concentrates on themes and key concepts rather than numerical data. It is also very easy for the results to be misinterpreted if they are isolated from the context of the group.

Advantages of focus groups

There are numerous advantages to using focus groups. One advantage is that they are a useful way of exploring knowledge and experiences in more detail than a questionnaire would allow. Another advantage of using focus groups instead of questionnaires is they can aid people who may have difficulty in reading and writing and thus filling in a questionnaire.

With focus groups, the use of several people often brings out ideas that others may not have thought of but will then develop and discuss. It is therefore a convenient way of collecting qualitative information from several people simultaneously. This is one of the mains reasons for their use in this research.

The use of a number of people in a focus group also has another added advantage, in that it encourages participation from anxious and wary talkers and involves people who may be dissuaded from communicating their attitudes in a one to one interview (Lederman, 1983). It allows the participants to feel empowerment.

3.3.7 The Delphi technique

Theoretical basis

The Delphi technique can be defined as a 'a method of systematic solicitation and collection of judgements on a particular topic through a set of carefully designed sequential questionnaires, interspersed with summarised information and feedback of opinions derived from earlier responses' (Delbecq et al, 1975). Its job is to determine the extent of consensus amongst experts.

The Delphi technique works by initially seeking the views of a group of experts about a particular issue. This can be done through meetings or through questionnaires. The aim is to probe views. These views are then summarised and categorised. These categories are then used to feed into a second more finely tuned meeting or questionnaire. Here the same group of respondents indicate how important they feel that certain items previously highlighted are, normally through a ranking process.

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The Delphi technique has been used in educational research in the past for various curriculum-based explorations (Haussler et al, 1980; Blair and Uhl, 1993; Doyle, 1993; Smith and Simpson, 1995). Its approach is suited to some of the research in this present study.

Disadvantages

Some of the disadvantages of this technique are the length of the process. There is a difficulty in assessing and fully utilising the expertise of the group because they never meet (Murry and Hammons, 1995). In fact due to the problem of waiting for responses from people, the research can take many months. This can led to a drop in the end number of respondents taking part. With this technique, in fact with many of the techniques mentioned in this chapter, there is also the possible problem of researcher influence on the responses due to particular question formulation.

Advantages

The use of the Delphi technique has many advantages. One of the most important of these is that it uses group decision-making techniques; involving experts in the field, leading to greater validity than would arise from an individual respondent (Brooks, 1979). Consensus reached by the group reflects reasoned opinions because the Delphi process forces group members to consider logically the problem and all the other factors involved (Murry and Hammons, 1995). In addition to this it allows anonymous group interaction and responses to take place. These opinions can be received from a group of experts who may be geographically separated from one another (Murry and Hammons, 1995). It also allows for easy statistical analysis (Cypher and Gant, 1983; Cochran, 1983; Uhl, 1983; Whitman, 1990)

3.4 METHODS USED IN THIS STUDY

Semi structured interviews and open questionnaires were the most appropriate qualitative method to use for this type of research. This was decided because it was thought that the respondents used in the present research would respond better to some gentle directives (Edwards, 2001) and as previously highlighted; they are useful methods for exploring attitudes and beliefs and developing closed item questionnaires. The quantitative methods chosen for this research are closed questionnaires because of their suitability for obtaining reliable and consistent responses. It also allows for a larger number of responses to be collected, thus producing more reliable results.

3.5 SAMPLE SELECTION

Samples can be stratified samples or purposive. When subpopulations vary considerably, it is advantageous to sample each subpopulation (stratum) independently. Stratification is the process of grouping members of the population into relatively homogeneous subgroups before sampling (Wikipedia, 2004). Purposive sampling on the other hand is where subjects are selected because of some characteristic.

A stratified selection was the most appropriate approach to use with this form of research as a result of time constraints. This is because it is not possible to track the students through their years of education within the time constraints of a PhD. For the research in the schools an educational directory was used. This gave roll numbers, religious background and gender mix of the schools. It was decided that all schools should be of mixed gender, non-religious, community comprehensive, schools in the North-West of England. From these a random selection of schools was chosen for the various methodologies that were used. The A-level students were obtained using a sixth form college directory for the Northwest. It was decided that non-religious sixth form colleges should be used. All students in Physics, Biology and English classes were included. The undergraduates were all chosen from within the University biology, physics and English departments and every student in the selected year was included. For the teachers a slightly different technique was used. Head of science departments were contacted in schools. Once permission was granted a letter contacted individual teachers within the science departments.

3.6 ANALYSIS OF DATA

The data obtained for the present study went through a series of levels of analysis. This ranged from the basic level of describing the data set and carrying out descriptive statistical procedures on the data to analytical statistics (e.g. chi squared) and more exploratory statistical approaches such as Factor Analysis. These will be further described in the relevant sections below.

3.6.1 Analysis of interviews

Interviews were recorded and transcribed into a standardised format. This format records the student's name, age and sex and also the school. This format is described in more detail in Chapter 4. The key concepts from the transcripts were then identified and emerging themes and ideas were used to further support findings from the closed questionnaires.

3.6.2 Analysis of Questionnaires

Responses to the questionnaires were coded and entered into the software package, Statistical Package for Social Scientists (SPSS). Numerical coding meant that quantification of the responses was possible.

For each respondent group descriptive statistics such as frequencies, tallies and means were produced. This enables the validity of the questionnaire to be observed. The distribution of responses to each question was compared between randomly split halves of the respondent group. From this a correlation coefficient could then be calculated. A result of over 0.6 was taken as being good evidence of correlation (Edwards, Stanisstreet and Boyes, 1997).

In the present study, since the data were categorical, chi squared (χ^2) a non-parametric test was applied to judge the statistically significant differences in responses of different groups of students, for example males and females. The levels of significance used are normally 5% to 1%. Further comparisons were made using the Wilcoxon ranking test when appropriate.

In some cases it was possible to apply the parametric paired sample t-test to compare differences in responses between biology and physics.

In order to search for common themes, the data were subjected to Varimax Rotated Factor Analysis (using the original 5-response category data). Factor Analysis is an exploratory statistical tool that uses responses to questionnaire items to create groups of items, or factors (Child, 1979). This method indicates connections between statements made by the different respondents. The factors are mathematically orthogonal and so represent independent groupings. For this reason, Factor Analysis may be useful in revealing cohesive themes in respondents' thinking (Boyes and Stanisstreet, 1993). The analysis produces a grid with a number of factors, each of which relates to every questionnaire item with a 'loading' between zero and unity. To interpret this grid, each factor is examined in turn and the questionnaire items with high loadings on that factor (above 0.35 in this case) are recorded. This was done to expose possible links between questionnaire items and so reveal possible themes in students' thinking.

Finally, regression analysis was occasionally used (again with the original 5-response category data) to explore which of the items about individual characteristics of the biology and physics might correspond to the general items concerning feeling ('liking' or 'disliking') for the subjects.

SCHOOL STUDENTS' CONSTRUCTIONS OF BIOLOGY AND PHYSICS

Chapter Four

4.1 INTRODUCTION

4.1.1 School students' attitudes to science

As highlighted in Chapter 1, the decline in the popularity of science is well known (Durrani, 1998). In order to understand why science is unpopular there has been considerable research exploring the attitudes of English school students to science (Young, 1993; Barber, 1993; Sheldrake, 1994; House of Commons 2002). Such research has explored their views about the science curriculum, their opinions of how science is taught, their ideas about the scientific process, their perceptions of scientists. In part, these have been driven by a concern about the continuing low take-up of science subjects and its possible effect on national economic performance. On the other hand, an appreciation of science is also seen as empowering participation in an increasingly technological society (Driver, Leach, Millar and Scott 1996).

Considerable research has also explored attitudes to school science in other areas of the world. In a conference held by the European Physical Society (2001) it was stated that the number of science university students in Germany has fallen dramatically in the past 7 years from almost 10 000 to just over 5000. In addition to the fall in the number of students it was noted that there were problems with the numbers of graduates who were electing to train as science teachers in both Sweden and the USA as well as in the UK (Editorial, Physics World 1999). This is reflected in the numbers of students graduating in physics and related subjects such as engineering, compared with those graduating in biological subjects. It is suggested that the problem of relatively few students taking physics at A-level and beyond may be self-perpetuating because it creates a shortage of physics teachers. Thus, many school students will be taught physics by teachers not formally qualified in that subject. Such students will be taught, or so the argument goes, with less enthusiasm and 'feel' for the subject than those taught by physics graduates, and so fewer students will be encouraged to study physics. However, research in Scotland has identified a different situation in student's choice of school science subjects. Here science, in particular physics, does not match the generally accepted picture (Skryabina, 2000). Scotland, in contrast shows that physics is the fourth most popular subject after English, mathematics and biology (Skryabina, 2000).

4.1.2 School students' attitudes to different sciences

Thus a considerable body of research has provided insight into students' views about science, what might inspire them and what might deter them from choosing to study science. However, the main thrust of many such studies has been to compare students' views about science, explicitly or implicitly, with their attitudes to non-science subjects; this approach may mask different attitudes to subjects within science (Woolnough, 1995). Indeed, the evidence suggests that school students do not view 'science' as an homogenous subject, but rather that they distinguish between branches of science. For example, the numbers of students who sat advanced A-level school examinations in

England and Wales 31 500 for physics compared with over 52 000 for biology (Institute of Physics, 2002), suggests that biology is considerably more popular than physics. In fact, physics is considered the most problematic area of science and attracts fewer students than either chemistry or biology. Osborne, Driver and Simon (1998) suggested *"Physics and Mathematics at School are only taken by students who do well and are not taken as incidental or additional subjects"*. Thus, physics is perceived as rather an elite subject, conceptually very difficult and more suited for the more able students. Although physics is seen as such, very little research has examined the differences in attitudes towards the different science subjects. The current research aims to investigate the underlying differences in attitudes towards physics, the relatively unpopular science, and biology, which does not appear to have followed, to the same extent, the decline in popularity.

4.1.3 Changes in attitudes to science of school students of different ages

At present, teachers have a general impression that, over the period of secondary schooling, students lose, or fail to gain, an enthusiasm for physics. Teachers may have intuitive ideas about when and why this happens, but there is little systematic evidence. Furthermore, the results of studies to explore the attitude of students of different ages have been inconsistent. Barrington and Henderiks (1988) found that there is a serious decline in the popularity of science between the ages of 8 and 12 followed by a dramatic improvement by age 16 (Skryabina, 2000). In contrast, Ramsden (1998) found that positive attitudes to science decrease over the years of secondary schooling; in addition, he showed that more negative views are associated with physics than with biology. The aim of the present study was to trace the changing attitudes of school students to physics and, as a comparator within science, biology over the period of secondary schooling, and to explore some of the possible reasons that underpin changes in their opinions. Identification of specific attitudes and of the time that they change, may allow education to devise strategies to reduce the generation of negative attitudes.

4.2 METHODS

4.2.1 Introduction

In order to gain an insight into students' attitudes towards physics and biology a series of methods were employed. As this was the first study carried out for this programme of research, the investigative tools had to be developed. The process involved designing a research instrument that would allow the students' constructions of biology and physics to be elicited. The process of this is described in the subsequent sections.

4.2.2 Design of open-form questionnaire

In order develop a closed-form questionnaire whose content was grounded in the thoughts and ideas of the students a series of steps was undertaken. The first step in the process was to develop an open-form questionnaire to probe students' views. The first questionnaire, therefore, was designed to allow students to express reasons for liking or disliking physics, and their reasons for liking or disliking biology. A sample version of this can be seen in Figure 4.1; the full version is given in Appendix 1. Two versions of this questionnaire were designed to compensate for any possible carry over effect from one item to the next. These two versions of the questionnaire were therefore interleaved, so that on distributing them one student received one version and their neighbour received the other version.

Figure 4.1 Example of open-form questionnaire items

Please write down a list of things you **like** about **Physics**. Please write as much as you can.

Please write down a list of things you **don't like** about **Physics**. Please write as much as you can.

In the actual questionnaire the box for students' response was large. Bold text is shown as in the actual questionnaire. One page of the questionnaire contained items about physics, as above; the other page contained paralleled items about biology

Administration of open-form questionnaire

The responses to this initial open-form questionnaire were scrutinized, and some of the ideas they contained were incorporated into the closed-form questionnaire. This was done by rating the responses according to the number of times that they had been raised by the students.

4.2.3 Interviews

A series of semi-structured interviews probing what characteristics of biology and physics that they think may impact on students' opinions were carried out.

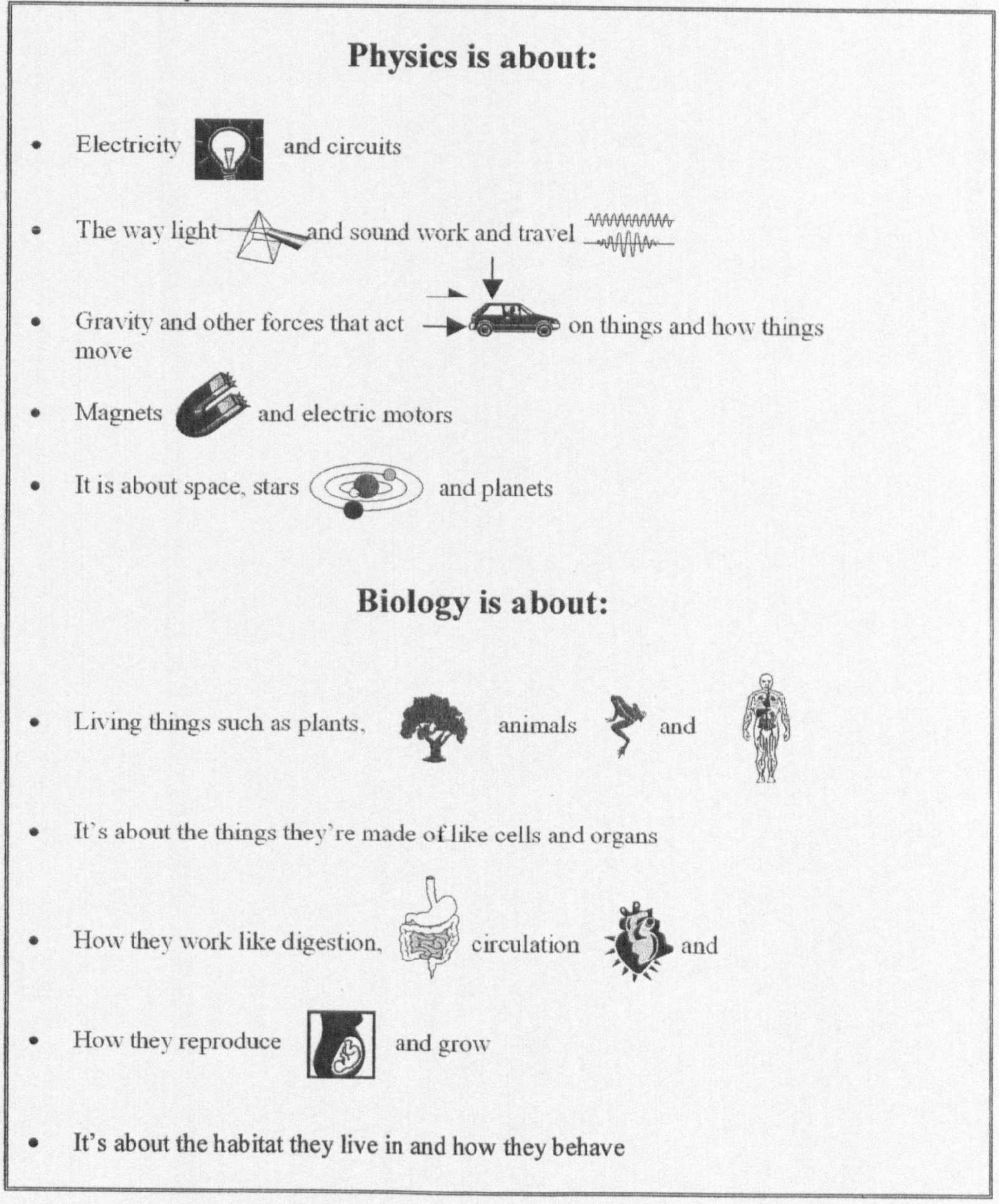
Both science teachers and several students from two schools took part in the interviews to gather ideas for the closed questionnaires.

4.2.4 The closed-form questionnaire

The most frequent statements from the open-form questionnaire were compiled into lists and used to develop the closed form questionnaire. Informal conversations were also held with teachers and school students. In addition, because the ways in which science subjects are communicated may be important, two items were included to probe students' perceptions about the language used in biology and physics.

In the closed-form questionnaire a 5-point Likert scale was employed to explore the students' attitudes. The first version of the closed form questionnaire was piloted in two secondary schools to assess whether the level of the wording and the layout of the questions were suitable. The results of this pilot, together with feedback from teachers, suggested that the wording was comprehensible to the youngest group of students (National Curriculum Year 7, age11-12 years). However, it was felt that an improvement to assist the youngest students, who might well think in terms of taking 'science' rather than biology, chemistry and physics, was needed. It was decided that illustrations of the topics within biology and physics would be helpful. So, examples of some of biology and physics themes, together with icons to illustrate them, were added to the coversheet of the questionnaire. The illustrations used were designed around the National Science Curriculum topics and were then discussed with teachers and fellow researchers. An example of the illustrations can be seen in Figure 4.2.

Figure 4.2 Illustrations of physics and biology used in the closed-form questionnaire



The final version of the closed-form questionnaire was arranged in three sections. The coversheet asked students to provide their year-group, age and gender, and gave examples of biology and physics topics. In addition, it contained two items asking students about their general feelings about biology and physics. The responses available to these two questions, illustrated by the biology item, were 'I really like biology', 'I quite like biology', 'I neither like nor dislike biology', 'I don't like biology much' and 'I really don't like biology'. This can be seen in Figure 4.3.

The other two sections of the questionnaire contained 16 items about biology and 16 about physics (Figure 4.4). Although the questions are grouped under themes when described in the Results section, they were in random order in the actual questionnaire and the order of the items about biology was different from that of the physics items.

The responses available to the questionnaire items, that were in the form of statements, were 'I strongly agree', 'I agree', 'I neither agree nor disagree', 'I disagree' and 'I strongly disagree'. The sections about biology and physics were reversed on two different versions of the questionnaires, distributed alternately to students, to compensate for any 'carry-over' effect from one section of the questionnaire to the next. An example of the statements can be seen in Figure 4.5 and a full version of the questionnaire can be seen in Appendix 2.

Figure 4.3 Example of the questionnaire coversheet

We are doing a big study to find out what people think about some of their different subjects in science, like Physics. We would like to know what you think.

First tell us a few things about yourself.

Your age…………..

Your year/class………..

Boy/girl…………..

If your parent(s) work what sort of job(s) do they do?

1. …………………………………

2. …………………………………

What do you feel about Biology?

☐	☐	☐	☐	☐
I really like Biology	I quite like Biology	I neither like nor dislike Biology	I don't like Biology much	I really don't like Biology

What do you feel about Physics?

☐	☐	☐	☐	☐
I really like Physics	I quite like Physics	I neither like nor dislike Physics	I don't like Physics much	I really don't like Physics

Figure 4.4 Example of items on the closed-form questionnaire

Coversheet items

What do you feel about biology?
What do you feel about physics?

Questionnaire items

Biology is a **boring** subject
There **are lots of different types of jobs** for people with biology
You need to be **good at maths** to do biology
Biology is more to do with **remembering facts** than understanding ideas
Biology is more of a **boys** subject
Biology can help to **solve medical problems**
Biology is an **easy** subject
Jobs for people with biology are **well paid**
People who really like biology **don't mix very well** with other people
Biology uses **easy, everyday words** but with a **different** meaning
Biology is an **interesting** subject
Biology is more of a **girls** subject
Biology can help people **solve** the world's **environmental problems**
You have to do **lots of work** in biology
Biology **uses difficult, complicated** words
The things I learn in biology **do not relate to my everyday life**

Figure 4.5 Example of a questionnaire statement

Physics is an interesting **subject**

☐	☐	☐	☐	☐
I strongly agree	I agree	I neither agree nor disagree	I disagree	I strongly disagree

4.2.4 Administration of the Questionnaire

Administration of the open-form questionnaire

The initial open questionnaire was piloted with two secondary schools. 280 students across the year groups 7,9,11 were questioned. Following analysis of the responses to this pilot questionnaire, the closed-form questionnaire was then developed.

Administration of the closed-form questionnaire

The first version of the closed-form questionnaire was piloted with 178 students in National Curriculum Years 7, 9 and 11. The final version of the closed questionnaire was administered to 1395 students from 6 non-religious, community comprehensive, mixed-gender schools in the North-West of England. Heads of Science were contacted by letter and then followed up by telephone. Schools were assured that the questionnaires were anonymous and that respondents could not be identified. Of the schools contacted, six agreed to take part.

The questionnaires were administered in science lessons. The students were not primed in any way. In all of the schools the researcher was present to administer the questionnaires. Students were instructed not to communicate with each other while they filled in the questionnaires and were told to be as honest as possible as the questionnaires were anonymous.

4.2.5 Analysis of responses from closed-form questionnaire

The students' responses were encoded into a Statistical Package for Social Scientists (SPSS) datasheet. To gain an insight into the reliability of the questionnaire, the distributions of responses to each question were compared between split halves of the respondent sample. The correlation coefficients between these two sub samples were calculated for each item on the questionnaire.

The responses of the students were explored using descriptive statistics. Percentages and frequencies of responses were initially worked out for each statement. Trends were identified by comparing the frequencies of responses for different variables such as gender, Year group etc. This was carried out by working out the percentage of students affirming the statement ('strongly agree' plus 'agree' responses) against Year group. The responses to parallel items in physics and biology were also compared. This was done using the non-parametric Wilcox Ranking test. This is used to test whether two samples are different. This was done for each year group. Chi-squared analysis was used to compare the responses of students in different year groups to individual questionnaire items. For chi-squared analyses, to clarify the interpretation of the statistical tests, the 'strongly agree' and 'agree' responses were combined, to give the proportion of students who affirmed the idea. Similarly, the 'neither agree nor disagree', 'disagree' and 'strongly disagree' responses were combined.

Rotates Varimax Factor Analysis was employed (using the original 5-response category data) to expose possible links between questionnaire items and so reveal possible themes in students' thinking.

Finally, regression analysis was used (again with the original 5-response category data) to explore which of the items about individual characteristics of the biology and physics might correspond to the general items concerning feeling ('liking' or 'disliking') for the subjects.

4.3 RESULTS

4.3.1 Analysis of pilot study

It become evident from some of the questionnaire responses that students were unable to distinguish between the different science subjects and instead just viewed them as 'science'. It was felt that an improvement to assist the youngest students, would be to illustrate some of the topics within biology and physics along with some extra text. Preliminary data analysis was carried out to determine the numbers of students giving different responses, to provide an indication of whether the students had completed the questionnaires properly. See Figure 4.2 for details of these illustrations

4.3.2 Description of the data set and reliability analysis

The main dataset consisted of 1395 students from 6 non-religious, community comprehensive, mixed-gender schools in the North-West of England. These students ranged from 11-16 years of age. Of the respondents, 52% were male and 49% were female. About 21% of the students were in National Curriculum Year 7 (age 11/12 years), 23% were in Year 8 (12/13 years), 19% were in Year 9 (13/14 years), 18% were in Year 10 (14/15 years) and 19% were in Year 11 (15/16 years). The mean correlation coefficient for all items from the randomly split halves of the respondents was 0.990, with a maximum of 1.000 and a minimum of 0.92. This indicated a high repeatability of responses.

4.3.3 Students' views about physics and biology

Although the questions were in random order on the actual questionnaire, here they are considered under a number of themes covered by the questionnaire. The distribution of responses to questionnaire items about views about science are summarised in the form of line graphs. The graphs are grouped into themes of the questionnaire;

- *the nature of biology and physics*
- *the academic demands of biology and physics*
- *the relevance and benefits of the biology and physics*
- *the communication of the biology and physics*
- *the nature of people who study biology and physics*

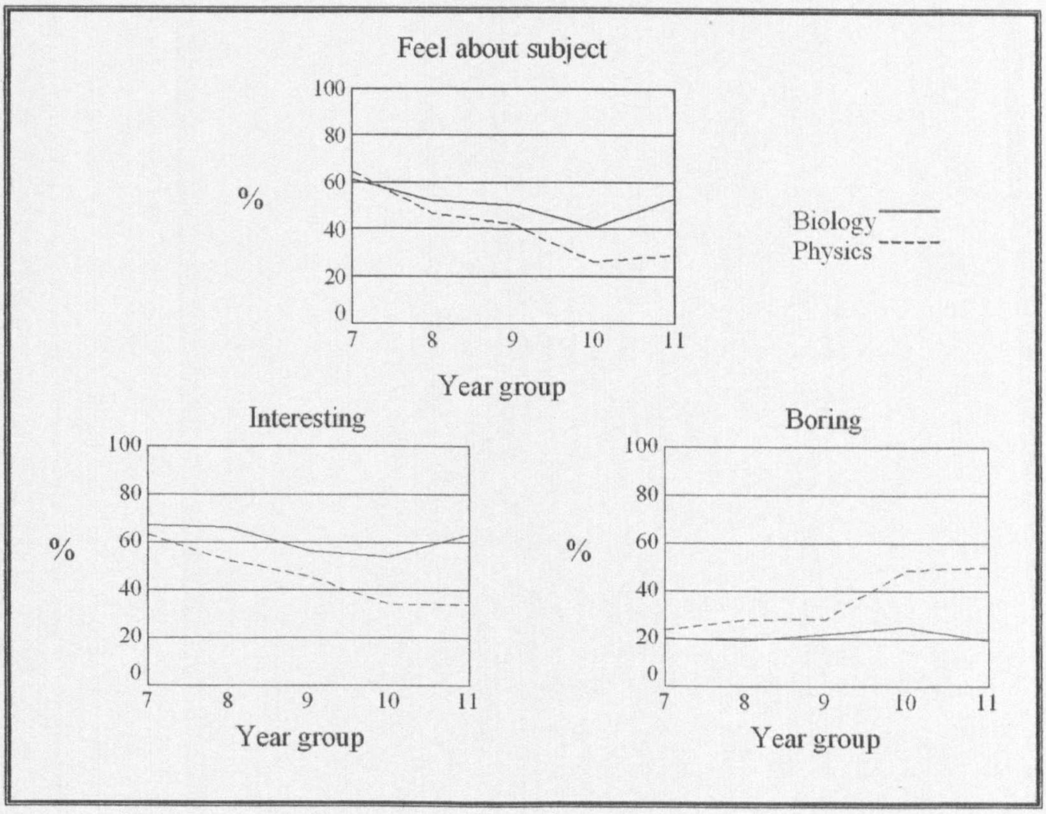
Data for the biology items are shown by the continuous line; data for the physics items are shown by the broken line. The ordinate represents the English and Welsh National Curriculum Year; the abscissa shows the percentage of students affirming the statement ('strongly agree' and 'agree' responses combined). In the description which follows, the percentages for biology are given first, followed by those for physics; where these are statistically significantly different the p value is shown.

The full details of the data may be found in the Appendix 4.3 located at the end of this chapter. Initially students were asked to identify how they felt about

Physics and Biology on a five-point scale. Figure 4.5 shows the number of students who 'really liked' or 'quite liked' the subjects.

Students' feelings and views about the nature of physics and biology

Figure 4.5 Students' feelings and views about the nature of physics and biology



Nearly two thirds of the students in Year 7 (aged 11-12) either 'really liked' or 'quite liked' biology and physics ('really like' and 'quite like' responses combined) (61%, 64%). However, in subsequent years the number of respondents who liked biology and physics had fallen, with there being a steeper drop for physics than for biology. By Year 11 the difference between students' feelings for the two subjects was such that significantly fewer students felt positive about physics than biology (52%, 29%, $p<0.001$).

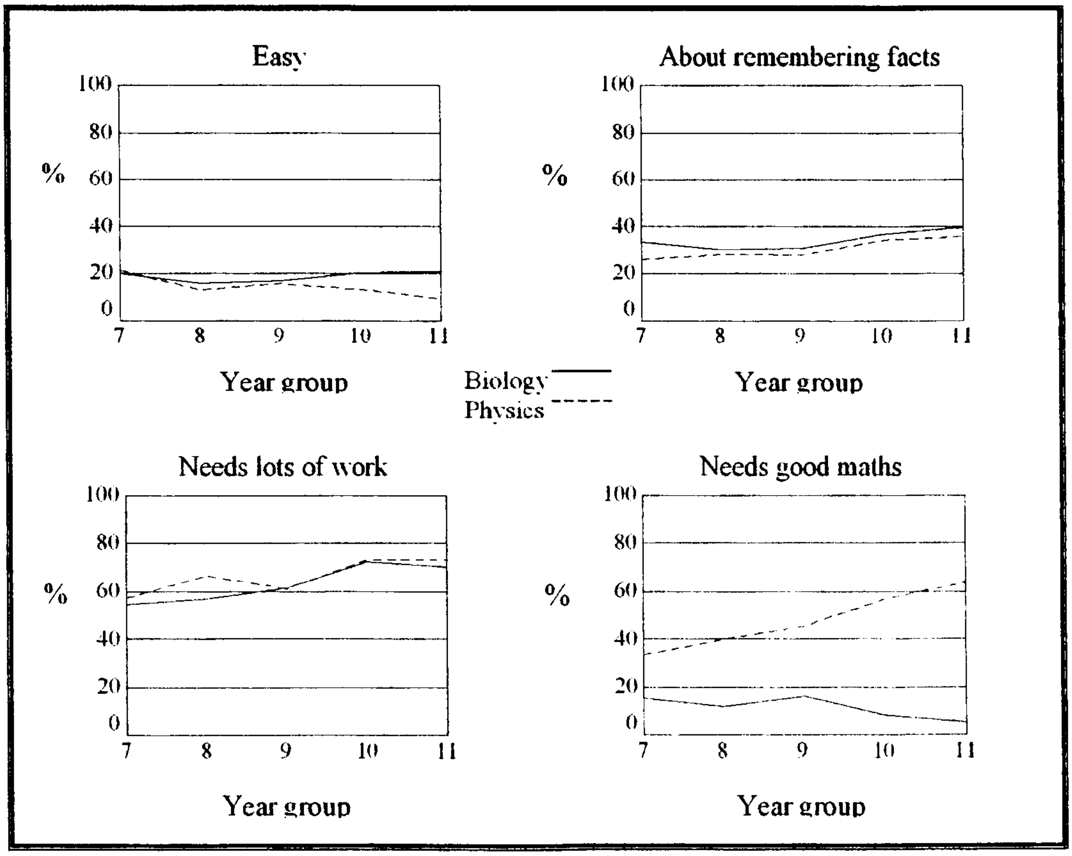
The questionnaire asked a series of questions concerning the nature of the physics and biology. The results of these are summarised in Figures 4.5. Some two thirds of the students in Year 7 found biology and physics interesting (67%, 63%) (Figure 4.6). Over the period of secondary schooling the interest of students towards biology only varied by 15%. A similar proportion of students in the oldest group found biology interesting as those in Year 7. However, the percentage of students finding physics interesting continuously fell over the period of secondary school to a third by Year 11 (34%), so that there was a significant difference between interest of students towards biology and physics by Year 11 (64%, 34%, $p<0.001$).

In a complementary manner, only about a fifth of the youngest students thought biology and physics were boring (20%, 24%) (Figure 4.5). Whereas this proportion remained almost identical for students in Year 11 for biology, half the students in Year 11 thought physics was boring (19%, 50%, $p<0.001$).

Students' views about the academic demands of biology and physics

The questionnaire also asked a series of questions about the academic demands of the subjects. Figure 4.6 compares the difference in responses for biology and physics.

Figure 4.6 Students' views about the academic demands of biology and physics



When asked about the ease of the subject a fifth of the students in Year 7 thought that biology and physics were easy (20%, 21%) (Figure 4.6). This remained relatively consistent for biology throughout the year groups but with physics there was a fall in the percentage of students who found it easy. This resulted in there being a significant difference in the number of students who found biology easy in comparison to physics by Year 11 (20%, 9%, $p<0.001$).

In terms of whether the subjects required rote learning, more than comprehension, there was no significant difference between the responses about biology or physics in Year 7 (33%, 26%) or 11 (40%, 36%)(Figure 4.6).

Although, for both subjects, there was at least a 10% increase in the number of students who thought that the subjects were about remembering facts

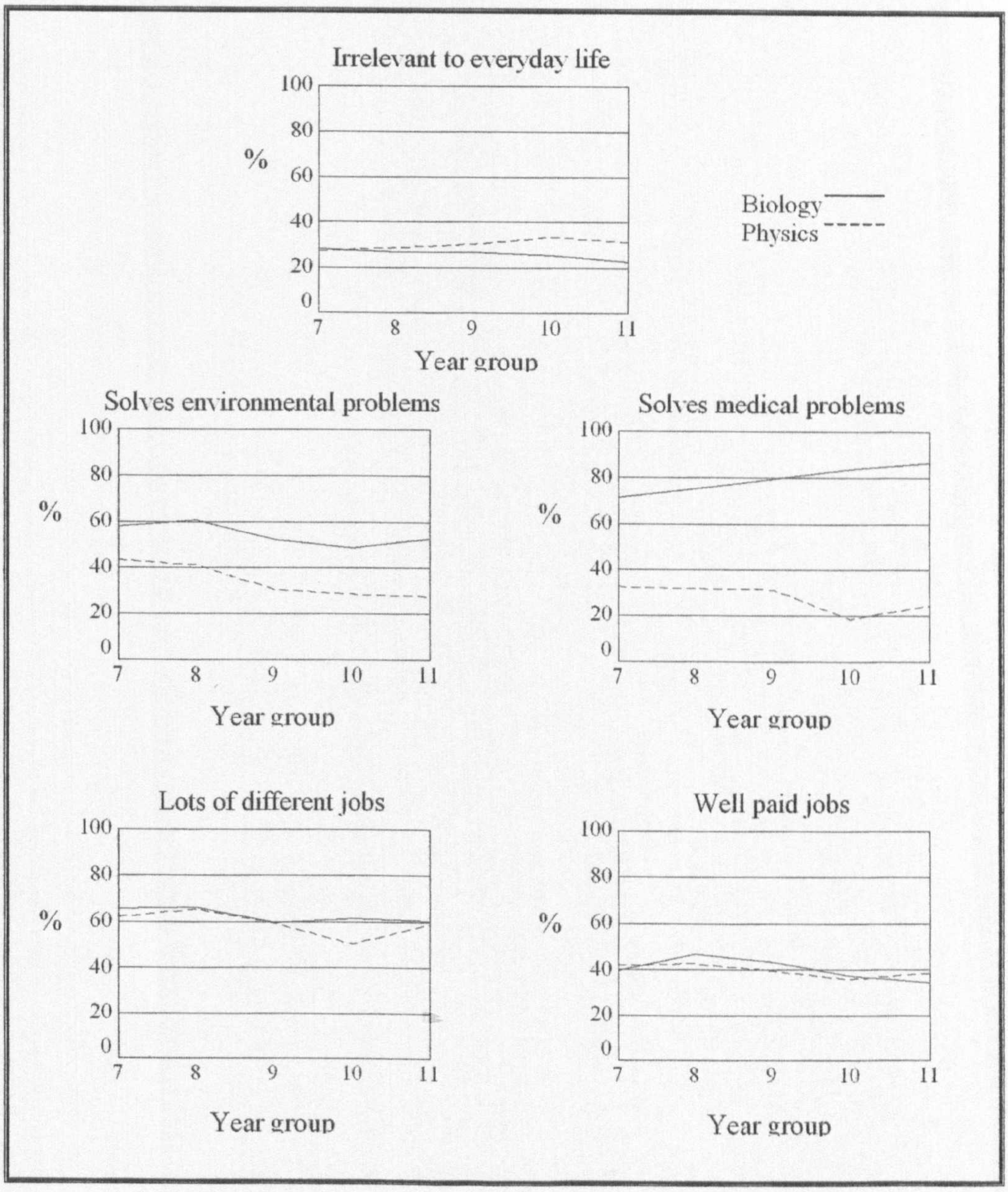
When asked about whether they thought that the subjects required lots of work, about half of the students in Year 7 thought that both biology and physics required lots of work (54%, 57%)(Figure 4.6). As the students progressed through secondary school, the percentage of student that thought the subjects required lots of work rose. By Year 11, three quarters of the population thought that there was a lot of work required (70%, 73%).

In Year 7 more students thought that an ability at mathematics was needed to study physics than biology (15%, 34%, $p<0.001$) (Figure 4.6). Even more students felt that physics required mathematical ability than biology in subsequent years. This difference was most marked with the Year 11 students, since the proportion who thought that mathematics was required to study physics had risen, whereas the proportion who thought that it was needed for biology had fallen (5%, 64%, $p<0.001$).

Students' views about the relevance and benefits of the biology and physics

Just over a quarter of the students in Year 7 thought that biology and physics were irrelevant to everyday life (28%, 27%) (Figure 4.7). The attitudes of students over the course of secondary schooling remained constant for biology.

Figure 4.7 Students' views about the relevance and benefits of biology and physics



However, the percentage of students in Year 11 that saw physics as irrelevant was significantly more than those who thought biology was irrelevant (22%, 33%, p<0.001).

In terms of social benefit, more students thought that biology rather than physics could contribute to the solution for environmental problems, both in the youngest group (58%, 43%, $p<0.001$) and in the oldest students (53%, 27%, $p<0.001$) (Figure 4.7).

The situation was even more extreme when students were asked about the potential for the subjects contributing to solutions to medical problems. Across the secondary school, biology was seen to help solve medical problems, significantly more than physics (Figure 4.7). Amongst the students in Year 7, more than twice as many thought that biology could contribute than physics (71%, 32%, $p<0.001$); by Year 11 the proportion of students believing that biology could contribute to medical problems had risen and the number who thought this of physics had fallen (87%, 24%, $p<0.001$).

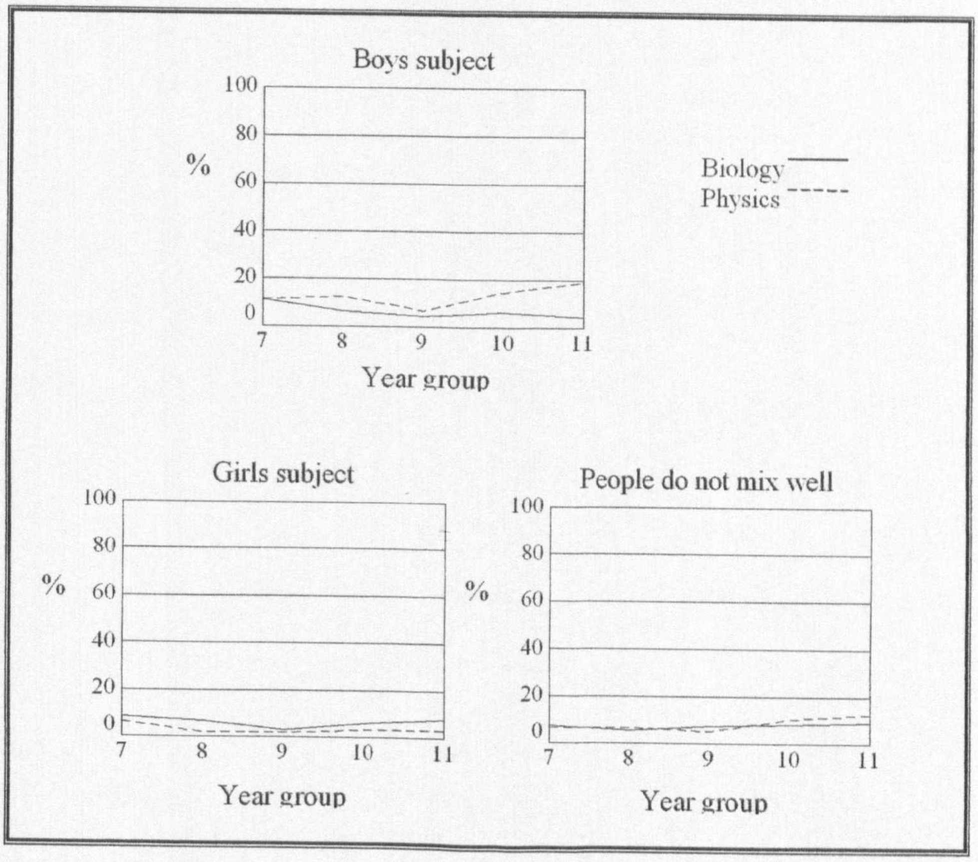
In terms of the personal benefits of the subjects, students thought that both physics and biology held good career prospects (Figure 4.7). About two thirds of the youngest group of students thought that a qualification in biology or physics would lead to a variety of employment opportunities (66%, 62%), and a similar situation obtained among the Year 11 students (60%, 59%).

Despite the number of students who thought that the subjects lead to good career prospects, over 20% fewer of the students thought that these jobs would be well paid. Of the Year 7 students (40%, 42%) thought that such jobs would be well paid. This did not significantly change much with the subsequent year groups. By Year 11 the percentage had only fallen slightly (34%, 39%)

Students' views about the types of people who study biology and physics

A series of questions were asked about the type of people that studied each subject, to try to determine what preconceived ideas students held about the suitability of the subjects to different personality types (Figure 4.8).

Figure 4.8 Students' views about the types of people who study biology and physics



When asked whether the subjects were more suitable for boys, just over a tenth of the students in Year 7 affirmed this idea for either biology or physics (11%, 11%). This trend followed through subsequent years up to Year 10. The students in Years 10 and 11, however, did start to show a difference in opinion for the different subjects. More students in Years 10 and 11 felt that physics was a boys subject. By Year 11, this difference was significant between the responses for biology and physics (4%, 19%, $p<0.001$).

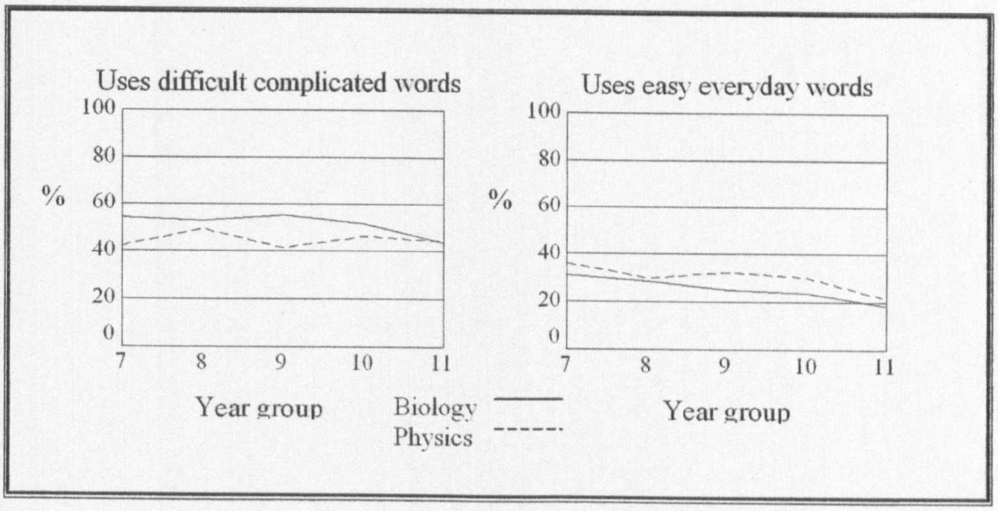
Very few of the students in Year 7 thought that biology or physics is more suitable for girls (8%, 7%)(Figure 4.8). This changed very little with students in subsequent years. Although a smaller proportion of students in Year 11 thought that physics is more suitable for girls (8%, 4%, $p<0.001$)

A further pair of items asked students if they thought that people who studied biology or physics were less sociable than others. Few of the Year 7 students thought this true for either subject (8%, 7%) (Figure 4.8). By Year 11, more of the students felt that this applied to people studying physics than biology (9%, 13%).

Students' views about the communication of the biology and physics

In Year 7 more students associated complicated, specialist terminology with biology than physics (53%, 42%, $p<0.001$) (Figure 4.9). This view of biology was held by a similar percentage of students across the year groups until students reached Year 11. In Year 11 the feeling that biology used difficult and complicated words had reduced. The proportion of Year 11 students that felt physics used difficult and complicated words was about the same as the percentage in Year 7. Just under half of students in Year 11 thought that biology and physics used difficult and complicated terminology (44%, 44%).

Figure 4.9 Students' views about the communication of the subject



About a third of the students in Year 7 associated both subjects with easy, everyday words used in a special way (32%, 36%) (Figure 4.19) . These proportions fell throughout the year-groups so that only a fifth of the Year 11 students thought that biology and physics employed vocabulary in this way (18%, 21%).

4.3.4 Themes of students' thinking.

From these analyses a general trend appeared in students' thinking about physics in Year 11 in comparison to those in the youngest age group, those in Year 7. The earlier year group appeared to hold similar opinions about biology and physics. However, students appear to generate differences in their views about these subjects over the period of their secondary schooling, such that students in the oldest group studied, Year 11 (aged 15/16 years), feel less positive overall about physics than biology, and had a number of specific negative views about physics. As a result of this, it was decided to explore further the data from the oldest age group. To do this, Factor Analysis was employed to seek themes of thinking in which students' specific ideas may be embedded (Boyes and Stanisstreet, 1993). The Factor analysis works by using a correlation matrix in which there are the same numbers of dimensions as questionnaire items. In order to extract components from this matrix the statistical package creates a variable (uni-dimensional) with the most variance (i.e. explains most of the variability in the questionnaire). The next variable with as much variance as possible (of what's left) is then found. This is repeated until all variance is extracted. Factor analysis then takes this one step further by rotating the new matrix of variables so that as few dimensions as possible explain the most variance as possible in the data. These will be ordered so that the first factor (group of variables or ideas within variables) explains the most variance. The items placed by factor analysis in each factor were examined for a common theme and then, if possible, the factor was 'named' to encapsulate the theme. Rotated Varimax Factor Analysis of the Year 11 students' responses produced 12 factors and extracted 67% of the total variance (Figure 4.10).

Some of the factors that were produced, considered first here, contained ideas only about biology *or* physics, suggesting that the Year 11 students differentiated between these aspects of the two subjects. Other factors, considered later, included ideas about both biology *and* physics, suggesting that students associated these aspects of the two subjects.

Factor 1 included questionnaire items that embraced ideas about only physics; whether or not it was generally likeable, interesting, easy and gave opportunities for a variety of jobs. In addition, the questionnaire item about physics being boring was included, but with a negative value suggesting an opposite polarity. The link between these items appears to be that of a general view of physics, so this factor was named '*Perceived characteristics of physics*'.

The second factor included a similar set of questionnaire items about biology. Thus, included in Factor 2 were the items about whether biology is likeable, interesting, easy and, with an opposite polarity, boring. Also included, but with a negative polarity, was the idea that people who enjoy biology are less sociable than others. So, Factor 2 was named '*Perceived characteristics of biology*'. The fact that such properties were distributed in different factors might indicate that Year 11 students distinguish between physics and biology in terms of these general characteristics. Factor 5 embraced the items concerning varied employment opportunities of physics and, with the opposite polarity, the item about whether physics was easy or not. However, the items with the highest factor loadings were those concerning the language of physics, about the use of everyday and specialist words, so this factor might be named '*Physics* *communication*'. Factor 8 included two items, about the application of physics to medical and environmental problems, so this was named '*Social benefits of physics*'.

Figure 4.10 Rotated Varimax Factor Analysis of responses of Year 11 students to items about biology and physics

	Factor Number											
Questionnaire item	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
P-Interesting subject	855											
P-How feel about?	846											
P-Boring subject	-811											
P-Easy subject	612				-494							
P-Lots of different jobs	433				388							
B-Boring subject		-853										
B-Interesting subject		847										
B-How feel about?		828										
B-Easy subject		495										
B-Girls subject			793									
P-Boys subject			785									
B-Boys subject			699									
P-Girls subject			674									
P-People don't mix well			601									
B-People don't mix well		-414	542									
B-Well paid jobs				719								
B-Lots of different jobs				587								
P-Well paid jobs				563								
B-Need mathematics				542								
P-Uses everyday words					-711							
P-Uses difficult words					632							
P-Irrelevant to everyday life						765						
B-Irrelevant to everyday life		-384				646						
B-Solve medical problems							702					
P-Need mathematics							656					
P-Solve medical problems								776				
P-Solve environmental problems								676				
B-Uses difficult words									788			
P-Needs lots of work										819		
B-Needs lots of work									485	512		
B-More remembering facts											754	
B-Uses everyday words											540	
B-Solve environmental problems												805
P-More remembering facts						396						402

Factors
1 Perceived characteristics of physics
2 Perceived characteristics of biology
3 Personal suitability for science
4 Science employment
5 Physics communication
6 Relevance of science
7 Not named
8 Social benefits of physics
9 Not named
10 Not named
11 Not named
12 Not named

97

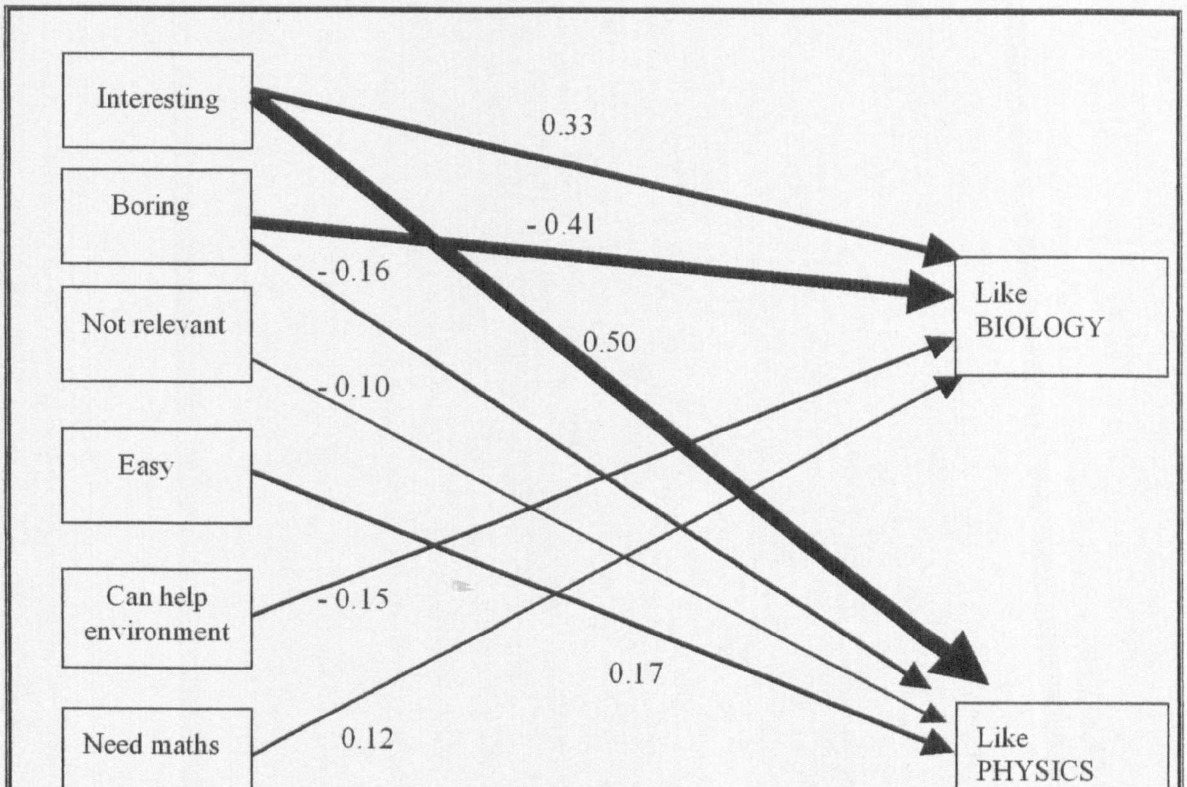
Other factors combined questionnaire items about both biology and physics. For example, Factor 3 was centred on items about the sorts of people who might or might not be suited to biology and physics; females, males and unsociable people. This factor was named '*Personal suitability for science*'. Factor 4 appeared to be about employment since it included the items about biology and physics giving opportunities for well-paid employment, and about biology leading to a variety of jobs. In addition, the item about biology needing mathematical abilities was included. The main theme here, however, seems to be that of '*Science employment*'. Factor 6 was centred on the relevance of both subjects to '*Relevance of science*'. None of the remaining factors had clear themes, so they were left unnamed.

4.3.5 Reasons underpinning differential views of Year 11 students

Following the results of the factor analysis, Regression Analysis was used to explore reasons that might underpin students' general feelings about biology and physics. Regression Analysis was performed using students' responses to the general item ('How do you feel about...') as the dependent variable.

In the case of biology, four of the variables showed significant associations. So, those students who like biology find it interesting ($p<0.001$) and not boring ($p<0.001$). Perhaps surprisingly, there were weaker (but still statistically significant) associations between a liking for biology and the ideas that knowledge of mathematics is needed ($p<0.005$) and that the subject does not particularly contribute to helping the environment ($p<0.001$). For physics, the responses to four specific questionnaire items showed significant associations with those from the general item about liking physics. Thus, those who like physics in this age group are more likely to be those who find the subject interesting ($p<0.001$) and reject the notion that it is boring ($p<0.05$) and, to a lesser extent, find physics easy ($p<0.001$) and relevant to their everyday life ($p<0.05$).

Figure 4.11 Reasons that might underpin Year 11 students' differential views about biology and physics



Arrows indicate associations between responses to the two questionnaire items concerning a liking for or disliking of the subjects (biology or physics), and gender and other questionnaires items. Strength of association is given by the values for the standardised beta co-efficient and illustrated by the thickness of the arrows.

4.4 DISCUSSION

4.4.1 Changes in students' attitudes to biology and physics

This part of the research has shown that as students progress through secondary school changes occur in their attitudes to both biology and physics. From the results it has become apparent that students appear to enter secondary schooling with an equal liking of biology and physics, perhaps not even distinguishing clearly between them and thinking more in terms of school 'science'. This is in line with what the government has been attempting to achieve over the last ten years. They have stated that science should not be seen as individual separate subjects but rather as a cohesive subject encompassing all three sciences (DfEE, 1989). At this stage their attitudes to science were relatively positive (Hadden and Johnstone, 1983; Woodward and Woodward,1998).

Over the period of secondary schooling, however, a reduction in the general popularity of both biology and physics was observed, reflecting the general fall in the appeal of science (Baird, 1997), although the decline in the popularity of physics is considerably greater than that of biology. This decline appears most noticeable from Year 10 onwards. Thus, whereas about half of the oldest group - those who are about to select their AS-level subjects - 'like' biology only about a quarter 'like' physics. Furthermore, there is a possibility that differential ascertainment might mask an even greater negative feeling towards physics among older students, with those who are most disaffected being less likely to attend.

The decline in the general popularity of physics is already documented (Barber, 1993; Young, 1993; Sheldrake, 1994). However, in the present study it was hoped that by asking students about various aspects of the individual sciences a greater understanding for the reasons behind the decline in the popularity of physics as apposed to biology could be found. As the results have shown, the change in general attitude is accompanied by changes in ideas about more individual aspects of the subjects.

4.4.2 Similarities between students' views about biology and physics.

Although there were many differences in attitudes to the sciences, in other cases the changes are effectively parallel in biology and physics. For example, both are increasingly seen as requiring a heavy workload. This might reflect a more general requirement for all subjects as students approach and enter the GCSE syllabus in Year 10. For instance, many schools expect an increasing commitment to homework as their students progress through secondary schooling - an aspect of workload that is immediately obvious to students. Similarly, there is a parallel change in attitude towards the language used by the sciences. Nearly half the students asked felt that both sciences use complicated words. Although initially more of the younger students thought this was the case for biology than for physics, by Year 11 this distinction had disappeared. The perceived use of easy, everyday words used in a special context also follows similar patterns for both the sciences, with initially more students in Year 7 thinking this was the case in comparison to Year 11 where this had dropped to about a fifth of the students. In the case of both these items, the reasons underpinning this trend may be that, by the time the students have reached Year 11, they have become familiar with the difficult terminology and words used in a different context to those that they had been previously used to, as a result of increased familiarity over the secondary years.

4.4.3 Differences between students' views about biology and physics

Of more significance, in the present context of why physics in particular is unpopular, is a consideration of students' ideas that change about physics but not about biology in an attempt to understand why physics is unpopular. An attempt has been made to categorise the aspects of physics and biology explored by the questionnaire that might motivate school students to choose to study physics, or deter them from so doing (Figure 4.11).

Figure 4.12 Factors which might motivate or deter students from liking physics

	Proximal Personal Reasons	**Distal Personal Reasons**	**Distal Social Reasons**
Motivators	* Interesting subject * Easy subject Uses everyday words	Lots of different jobs Well-paid jobs	* Help environmental problems * Help medical problems
Deterrents	* Boring subject * Irrelevant to everyday life Lots of work Students don't mix well Uses difficult words		
Student-dependent whether Motivator or Deterrent	* Subject needs maths * Boys subject * Girls subject Facts, not understanding		

Asterisks* indicate ideas for which students' responses were significantly different between physics and biolog

Thus, some characteristics might be categorised as being of immediate importance to students while they study the subject; these have been termed ‘proximal reasons’. For example, it is possible to imagine that a subject that is perceived as easy, interesting and taught in a readily-accessible language would be ‘liked’ by students, whereas one that is perceived as boring and irrelevant would not. Other ideas might be thought of as having less immediate importance to students; these have been termed ‘distal reasons’. Some of these distal reasons are personal - the potential of a wide choice of careers and well-remunerated employment are examples. Others are less personal. Even these, however, effect the overall social and physical environment in which the students will live and may appeal to altruistic attitudes of students. The potential to contribute to environmental improvement or to the solution to medical problems are examples.

Figure 4.11 is annotated to indicate those characteristics that are perceived by Year 11 students as being different for physics and biology. It can be seen that many of the proximal reasons, those likely to have impact on students perceptions of the subjects and thus choice of AS- and A2-level subjects, are included in the ideas in which students distinguish between biology and physics, to the detriment of physics. For example, there is a decline in the proportion of students who find physics (but not biology) interesting and a complementary rise in the percentage that find it boring. This is significant in that there is evidence that students who find a subject interesting do actually choose it for further study (Watson, McEwen and Dawson, 1994). Similarly, there is a drop in the proportion of students who think that physics is easy which may lead, in turn, to the development of a negative attitude to physics (Rennie and Punch, 1991). Perhaps related to this, there is an increasing view that physics requires strong mathematical ability, whereas the reverse is true of views about biology, although many academic and professional biologists would be disappointed to think that students believe that biology becomes less quantitative as it becomes more advanced. Nevertheless, these differing perceptions may encourage students interested in science to select biology rather than physics at AS- or A2 level. One might imagine that in the minds of school students, 'relevant' and 'interesting' are effectively synonymous, in that issues that are perceived as being of immediate relevance are likely to be of interest. More distal factors such as employment prospects did not appear to bear heavily on students' general liking or disliking of physics at the time of questioning.

When exploring the reasons for the change in students' views over secondary school years there may be two main areas. One possibility may be that based on changes in the student whilst another may be as a result of the subjects themselves. Students' frame of reference may alter as they progress through the years as a result of various influences such as peers, media or the teaching styles. Another possibility may be that the actual nature of the subject changes. For example does physics get less descriptive, less concrete and more conceptual, abstract and mathematical as the student's progress though secondary schooling? One further, likely possibility is that both the students' frame of reference and the nature of the subject changes and in the cases of physics this change is more negative than for biology.

Quantitative studies of this kind provide information on a population basis and there is a need to remember that students are not an homogenous population in terms of their attitudes to physics (Roth and Roychoudhury, 1993), and may therefore not be attracted by the same characteristics. Any change in the content or presentation of the physics syllabus should be undertaken with caution. It would be frustrating to attract a new cohort of students to physics only to find that the type of student who was traditionally attracted to physics was then dissuaded from choosing physics.

Thus it seems clear that by Year 11 students have established differential attitudes to biology and physics, with physics being viewed more negatively. It has become apparent in this research that students use the words interesting and boring to describe their feelings towards the subjects without us really having a true understanding about what they actually mean by these words. As a result of this the next chapter will explore what students mean by interesting and boring in a hope to further explore the feelings towards physics and biology.

Appendix 4.1

Instructions given out to teachers

THE UNIVERSITY *of* LIVERPOOL

Science Communication Unit

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Teachers' Guidelines

Thank you very much for helping with our study of young people's perceptions of physics and biology. We do appreciate that teachers have many demands on their time, so we are especially grateful.

So that the procedures in this study are kept consistent in the different schools involved, it would helpful if you would follow the guidelines below.

Please

- Hand out the questionnaires in the order in which they have been arranged - they have been deliberately 'interleaved'
- Do not provide any further information to the students about physics or biology
- Ensure that the students answer the questionnaires in class, and that they do not take them away to complete
- Ensure that the students do not to confer with one another when answering the questions
- Ensure that students complete the details on the first page before starting the questionnaire - the indication of their National Curriculum Year group is especially important
- Thank your students on our behalf

After the students have completed the questionnaires, please place the completed questionnaires in the folder provided.

May we thank you again for taking time to help us with this study.

Katherine Spall
Research Student

Appendix 4.2

Questionnaire given out to Students

These questions are about Physics

Physics is an **interesting** subject

☐ I strongly agree ☐ I agree ☐ I neither agree nor disagree ☐ I disagree ☐ I strongly disagree

You need to be **good at maths** to do physics

☐ I strongly agree ☐ I agree ☐ I neither agree nor disagree ☐ I disagree ☐ I strongly disagree

Physics can help people solve the world's environmental problems

☐ I strongly agree ☐ I agree ☐ I neither agree nor disagree ☐ I disagree ☐ I strongly disagree

Physics is more of a **boys** subject

☐ I strongly agree ☐ I agree ☐ I neither agree nor disagree ☐ I disagree ☐ I strongly disagree

There are lots of **different types of jobs** for people with physics

☐ I strongly agree ☐ I agree ☐ I neither agree nor disagree ☐ I disagree ☐ I strongly disagree

Physics is a **boring** subject

☐ I strongly agree ☐ I agree ☐ I neither agree nor disagree ☐ I disagree ☐ I strongly disagree

Physics is more to do with **remembering facts** than understanding ideas

☐ I strongly agree ☐ I agree ☐ I neither agree nor disagree ☐ I disagree ☐ I strongly disagree

The things I learn in physics do not **relate to my everyday life**

☐ I strongly agree ☐ I agree ☐ I neither agree nor disagree ☐ I disagree ☐ I strongly disagree

People who really like physics **don't mix very well** with other people

☐ I strongly agree ☐ I agree ☐ I neither agree nor disagree ☐ I disagree ☐ I strongly disagree

Physics can help to **solve medical problems**

☐ I strongly agree ☐ I agree ☐ I neither agree nor disagree ☐ I disagree ☐ I strongly disagree

Physics is more of a **girls** subject

☐ I strongly agree ☐ I agree ☐ I neither agree nor disagree ☐ I disagree ☐ I strongly disagree

Physics uses **difficult, complicated** words

☐ I strongly agree ☐ I agree ☐ I neither agree nor disagree ☐ I disagree ☐ I strongly disagree

Jobs for people with Physics are **well paid**

☐ I strongly Agree ☐ I agree ☐ I neither agree nor disagree ☐ I disagree ☐ I strongly disagree

Physics is an **easy** subject

☐ I strongly agree ☐ I agree ☐ I neither agree nor disagree ☐ I disagree ☐ I strongly disagree

You have to do **lots of work** in Physics

☐ I strongly agree ☐ I agree ☐ I neither agree nor disagree ☐ I disagree ☐ I strongly disagree

Physics uses **easy, everyday words** but with a **different meaning**

☐ I strongly agree ☐ I agree ☐ I neither agree nor disagree ☐ I disagree ☐ I strongly disagree

These questions are about Biology

Biology is a **boring** subject

☐ I strongly agree ☐ I agree ☐ I neither agree nor disagree ☐ I disagree ☐ I strongly disagree

There are lots of **different types of jobs** for people with biology

☐ I strongly agree ☐ I agree ☐ I neither agree nor disagree ☐ I disagree ☐ I strongly disagree

You need to be **good at maths** to do biology

☐ I strongly agree ☐ I agree ☐ I neither agree nor disagree ☐ I disagree ☐ I strongly disagree

Biology is more to do with **remembering facts** than understanding ideas

☐ I strongly agree ☐ I agree ☐ I neither agree nor disagree ☐ I disagree ☐ I strongly disagree

Biology is more of a **boys** subject

☐ I strongly agree ☐ I agree ☐ I neither agree nor disagree ☐ I disagree ☐ I strongly disagree

Biology can help to **solve medical problems**

☐ I strongly agree ☐ I agree ☐ I neither agree nor disagree ☐ I disagree ☐ I strongly disagree

Biology is an **easy** subject

☐ I strongly agree ☐ I agree ☐ I neither agree nor disagree ☐ I disagree ☐ I strongly disagree

Jobs for people with biology are **well paid**

☐ I strongly agree ☐ I agree ☐ I neither agree nor disagree ☐ I disagree ☐ I strongly disagree

People who really like biology **don't mix very well** with other people

☐ I strongly agree ☐ I agree ☐ I neither agree nor disagree ☐ I disagree ☐ I strongly disagree

Biology uses **easy, everyday words** but with a **different meaning**

☐ I strongly agree ☐ I agree ☐ I neither agree nor disagree ☐ I disagree ☐ I strongly disagree

Biology is an **interesting** subject

☐ I strongly agree ☐ I agree ☐ I neither agree nor disagree ☐ I disagree ☐ I strongly disagree

Biology is more of a **girls** subject

☐ I strongly agree ☐ I agree ☐ I neither agree nor disagree ☐ I disagree ☐ I strongly disagree

Biology can help people solve the world's environmental problems

☐ I strongly Agree ☐ I agree ☐ I neither agree nor disagree ☐ I disagree ☐ I strongly disagree

You have to do **lots of work** in biology

☐ I strongly agree ☐ I agree ☐ I neither agree nor disagree ☐ I disagree ☐ I strongly disagree

Biology uses **difficult, complicated** words

☐ I strongly agree ☐ I agree ☐ I neither agree nor disagree ☐ I disagree ☐ I strongly disagree

The things I learn in biology do not **relate to my everyday life**

☐ I strongly agree ☐ I agree ☐ I neither agree nor disagree ☐ I disagree ☐ I strongly disagree

Appendix 4.3

Percentage of students in each year group that agree or strongly agree with questionnaire statements for biology and physics

Percentage of students in each year group that agree, strongly agree with questionnaire statements for biology and physics

Statements	Year 7		Year 8		Year 9		Year 10		Year 11	
	Biology	Physics	Biology	Physics	Biology	Physics	Biology	Physics	Biology	Physics
% liking the subject	61%	64%	52%	46%	50%	42%	40%	26%	52%	29%
% finding the subject boring	20%	24%	19%	28%	22%	28%	25%	49%	19%	50%
% finding the subject interesting	67%	63%	67%	53%	57%	46%	54%	34%	63%	34%
% thinking you have to be good at maths	15%	34%	12%	40%	16%	45%	8%	57%	5%	54%
% affirming there are lots of different jobs	66%	62%	66%	65%	60%	59%	62%	50%	60%	59%
% affirming there are well paid jobs	40%	42%	47%	43%	44%	40%	37%	36%	34%	39%
% affirming that it's about remembering facts	33%	26%	31%	28%	31%	28%	37%	34%	40%	36%
% affirming that it's a boys subject	11%	11%	6%	12%	4%	6%	6%	15%	4%	19%
% affirming people doing the subject don't mix well	8%	7%	6%	7%	75	5%	8%	10%	9%	13%
% affirming that it is a girls subject	8%	7%	7%	2%	3%	2%	6%	3%	8%	4%
% that affirm it uses difficult complicated words	53%	42%	53%	49%	55%	41%	52%	46%	44%	44%
% affirming use of everyday words with a different meaning	32%	36%	28%	30%	25%	32%	23%	30%	18%	21%
% the subject can help solve world's environmental problems	58%	43%	60%	41%	52%	30%	48%	28%	53%	27%
% affirming subject involves lots of work	54%	57%	57%	67%	62%	61%	72%	73%	70%	73%
% affirming subject helps solve medical problems	71%	32%	75%	32%	80%	31%	84%	18%	87%	24%
% affirming it is an easy subject	20%	21%	16%	13%	17%	16%	20%	13%	20%	9%
% affirming it does not relate to everyday life	28%	27%	27%	29%	27%	30%	25%	34%	22%	31%

SECONDARY SCHOOL STUDENTS' REASONS FOR CONSIDERING SCIENCE INTERESTING OR BORING

Chapter Five

Chapter 5

5.1 INTRODUCTION

In Chapter 4, school students' constructions of physics and biology were explored. One of the key differences in students' responses to parallel questionnaire items about physics and biology was that they perceived biology as relatively interesting and physics as comparatively boring. Furthermore, the responses to questionnaire items about whether physics is interesting or boring correlated with those to the item exploring their general like or dislike of physics. Thus, it seems that a major reason that could underpin students' increasingly general negative feelings towards physics is their perception of it as boring. This is significant in that there is evidence that students who find a subject interesting tend to choose it for further study (Watson, McEwen and Dawson, 1994). Thus, students' perceptions of physics as 'boring' might contribute to the low uptake of physics at A-level and beyond.

Students use words such as 'interesting' and 'boring' in a fairly loose manner, so it is not entirely clear what students may mean when they report physics as being 'boring'. Haussler *et al* (1998) criticised the rather narrow understanding of what is meant by 'interest' among researchers in science education. They have shown that, by looking at specific areas of interest, the picture looks rather different:

> *"beside being more or less interested, say in physics, people may have qualitatively rather different interest structures. There might be people who are highly interested in physics when it comes to a discussion of social implications of physical technologies, but are rather bored by a mathematical description of physical phenomena. There might be others who are attracted by the mathematical formalism of physics, but dislike the engagements in societal matters."*

Haussler *et al.*, 1998

The aim of this section of the present study, therefore, is to explore further what school students mean when they describe physics as being 'boring' - what is driving the generation of their negative view of physics?

5.2 METHODS

5.2.1 Design of the questionnaire

In order to gain further insight into students' descriptions of physics and biology 'boring' or 'interesting' a combined open-form and closed-form questionnaire was developed. The questionnaire contained parallel sections about physics and biology. Each section had two items. The first section, a closed-form item, asked students whether they found physics (or, in the parallel section, biology) 'very interesting', 'interesting', 'neither interesting nor boring', 'boring' or 'very boring'. An open-form item in which students were invited to 'tell us why you think this' followed this. The questionnaire wording encouraged students to write 'as many reasons as you can'. A sample version of this can be seen in Figure 5.1.

Figure 5.1 Example of closed-form questionnaire item

What do you feel about Biology?

☐	☐	☐	☐	☐
Very interesting	Interesting	Neither interesting nor boring	Boring	Very boring

In order to compensate for any possible 'carry-over' effect from the first section of the questionnaire to the second, two versions of the questionnaire were produced, one with the questions about biology first, the other with the questions about physics first. The two versions were issued alternately to students. During the completion of the questionnaire, examination conditions prevailed, although no time limit was imposed. The questionnaire was piloted in one school with 60 Year 10 students and the responses indicated that the wording was appropriate to the age group concerned, so the questionnaire was not modified.

5.2.2 Administration of the final questionnaire

Ten non-religious, community comprehensive, mixed gender schools were randomly chosen in different areas in the NorthWest of England. The schools were not the same as those in the previous chapter. Heads of Science were contacted by letter and then followed up by telephone. Schools were assured that the questionnaires were anonymous and that respondents could not be identified. Of the schools contacted, six agreed to take part, and the questionnaire was completed by 317 students in National Curriculum Year 10 in these schools.

The questionnaires were administered in science lessons. The students were not primed in any way. In all of the schools the researcher was present to administer the questionnaires. Students were asked not to communicate with each other while they filled in the questionnaires and were told that they should be as honest as possible and that the questionnaires were anonymous.

5.2.3 Analysis of the questionnaire responses

Initially, the distribution of the different responses to the closed-form questionnaire items were calculated. Following this, in order to compare the responses of different subsets of students, the 'very interesting' and 'interesting' responses were combined, as were the 'boring' and 'very boring' responses. Chi squared tests were carried out to determine whether there were any significant differences between sub-sets of students.

The completed open-form sections of the questionnaire were scrutinized and four lists of ideas raised by students were compiled. One list of views was prepared for those students who had responded to the closed item about physics that they found it 'very interesting' or 'interesting'. A separate list was constructed for those students who reported that they found physics 'boring' or 'very boring'. Two corresponding lists were produced for the biology section of the questionnaire. When the lists were completed, the ideas were arranged in categories and, following this, any ideas that were very similar were pooled. Each category was then given a code, and an Excel spreadsheet was constructed in which each category code was assigned a column. The questionnaires were then re-examined and the ideas raised by each student were encoded onto the Excel spreadsheet. The data were then imported into an SPSS data file for analysis. In some cases, idea categories were pooled into more general groups.

5.3 RESULTS

5.3.1 Description of the respondent group

The main dataset consisted of 317 National Curriculum Year 10 students from 6 non-religious, community comprehensive, mixed-gender schools in the NorthWest of England. These students were from National Curriculum Year 10. Of the respondents, 44% were male and 56% were female.

5.3.2 Proportion of Year 10 students finding biology and physics interesting or boring

The distribution of responses to the closed-form questionnaire items probing students' general attitudes to biology and physics are summarised in tables in Figure 5.2.

About half of the Year 10 students (57%) found biology very interesting or interesting, and about a quarter (21%) found it boring or very boring. In contrast, only about a quarter of the students (26%) thought that physics was very interesting or interesting and about half (49%) thought it boring or very boring. This supports the findings of the previous study described in Chapter 4 in which 54% of Year 10 students thought that biology was interesting and 25% thought it boring, and 34% of the Year 10 students thought that physics was interesting whilst 49% thought it boring. There was no significant difference in the responses of the males and females to the closed-form item about biology, whereas statistically significantly fewer females than males thought that physics was interesting (8%, 4%, $p < 0.001$). Thus, the results to this section of the questionnaire support the contention that students find physics less interesting than a comparator science subject, biology, and that fewer girls than boys find physics interesting.

Figure 5.2 Proportions of Year 10 school students finding biology and physics interesting or boring

	Biology	Physics
	All	All
	%	%
Very interesting	10	6
Interesting	47	20
Neither interesting or boring	22	26
Boring	15	25
Very boring	6	24

Predominant reasons for school students finding biology and physics boring

The responses provided for finding the biology or physics boring were grouped according to subject and then arranged into idea categories of similar themes. A number of the reasons that were given for finding physics and biology boring were similar (Figure 5.3). For both subjects some students stated that it was the lack of enjoyment in the subject that made it boring. The main reason for finding biology boring was that it was seen as a difficult subject although, in contrast, a few students thought the reverse, that it was boring because it was too easy. Another frequent reason for finding biology boring was because it was seen as repetitive or predictable. The dearth of practical work was also raised as a reason for finding biology boring.

Almost half the students thought that the difficulty of the subject was a major reason for finding physics boring, although, as with biology, a few students thought that physics was boring because it was too easy. Another common reason was that the subject was 'not relevant', either to everyday life or to other subjects. It was found that a fifth of the students, stated curriculum areas or specific topics as examples to support their statements.

Figure 5.3 Predominant reasons for Year 10 school students finding biology or physics boring

Category of reason	Biology %	Physics %
Difficult/hard subject	29	48
Subject too easy	3	11
Do not enjoy subject	12	30
Content of subject	6	20
Too little practical work	14	7
Subject repetitive/predictable	18	6
Subject irrelevant	0	14

Percentages may total more than 100 because individual students offered more than one reason. Data are given as a percentage of those thinking that biology (or physics) was very interesting or interesting in responses to the closed questionnaire

Predominant reasons for Year 10 school students finding biology or physics interesting

Those finding the subjects interesting supported many of the views of students finding biology or physics boring in a complementary manner. For example, some students found biology or physics boring because they did not enjoy the subject, similarly, some students found biology or physics interesting did so because they enjoyed it. For both biology and physics, some students stated that they found the subjects interesting because they were easy, although a few students, a higher proportion in the case of physics, found the challenge of the subject interesting. Some students wrote that the relevance, or that the variety of topics within the subjects, made them interesting. However, the two most predominant reasons for finding both biology and physics interesting were the content of the curriculum and the practical nature of the subjects. The former played a greater role in making biology interesting to students; the latter played a greater role in convincing students that physics was interesting.

Figure 5.4 Predominant reasons for Year 10 school students finding biology or physics interesting

Category of reason	Biology %	Physics %
Easy subject	18	14
Enjoy subject	32	10
Subject offers a challenge	1	9
Content of subject	59	40
Practical exercises	28	46
Relevance of subject	8	19
Variety of subject	5	12

Percentages may total more than 100 because individual students offered more than one reason. Data are given as a percentage of those thinking that biology (or physics) was very boring or boring in responses to the closed questionnaire

Topics in physics found boring or interesting by Year 10 school students

In the section of the study discussed in Chapter 4 the curriculum content and subject topics were not addressed. However, in the present section of the study a number of students raised various aspects of the curriculum as reasons for finding physics interesting or boring (Figure 5.5).

Certain topics, such as electricity, energy, forces and mathematical aspects, were given by some students as a reason for physics being seen as both boring, and by other students as a reason for it being interesting.

Figure 5.6 Topics in physics found boring or interesting by Year 10 school students.

Specific content of physics found boring or interesting	Boring %	Interesting %
Electricity	3	8
Energy	1	8
Forces	2	5
Mathematical aspects	15	12
Circuits		4
Colour/spectrum		1
Magnetism		3
Nuclear Energy		3
Solar system/universe		6

Figures are given as a percentage of those thinking that physics was very boring or boring, or very interesting or interesting, in responses to the closed questionnaire item.

Thus, the impact of certain topics on an individual student's overall perception of physics depends upon the individual student's predilections. Other topics were raised only in the context of physics being found interesting; circuits, magnetism, nuclear energy and 'the universe' were examples. Predominant among these was a liking for areas of the curriculum covering the solar system or 'space'. Although a larger respondent sample may have revealed some students who raised these aspects as being boring, the majority of students appear to find them interesting aspects of physics.

5.4 DISCUSSION

This section of the study was carried out to explore further the reasons underlying students' feelings towards biology and physics. The aim was to understand more about why students may lose interest in physics over the course of secondary schooling. It was hoped that this study would highlight ways in which students' interest in physics might be enhanced. However, one underlying factor that has appeared as a result of this study is that the very thing that attracts some students to the subject has an opposite effect on other students. For example, in terms of the content of the physics curriculum, some topics appear to attract some students but deter others. As a consequence, emphasis or reduction of such topics might, overall, prove ineffective in attracting more students to physics. Other areas of the curriculum, however, appear to attract some students with little deterrence on others. 'Space' was an example raised by the students in the present section of the study, perhaps because of its links to science fiction in the popular media (Watson, 2000). One strategy, therefore, might be to extend the way in which less popular areas of physics are exemplified by reference to the more popular examples. Perhaps more could be made of a discussion of the forces applied to a spacecraft during takeoff and in space, and the storage and use of energy sufficient for space travel. It might even be possible to convince students that for space exploration such questions require mathematical, not just qualitative, solutions. The present findings, understood intuitively by science teachers, that certain topics are inherently popular with students while others are inherently unpopular has a bearing on the recent suggestion that science should be taught using study themes.

Another major influence on whether students find a subject interesting appears to reside in whether they perceive it as 'relevant' (Woolnough, 1994). In the present study 'relevance' was given as a reason for finding both biology and physics interesting, and 'lack of relevance' as a reason for finding them boring. This idea was reinforced by the specific curriculum areas that students raised in the context of finding the subject interesting, particularly for biology. One might easily imagine how school students find the issues they raised in this context - the human body, the 'facts of life', and personal health issues such as smoking and drinking- as relevant to their everyday lives. However, a few students also raised the notion of the degree of relevance of the subject to other parts of the formal school curriculum. The challenge here, then, is to make physics less daunting to school students while retaining its essential nature.

It has been known for many years that girls are less attracted to physics than are boys (Garratt, 1986). In effect, physics fails to attract a large proportion of its potential constituency. Due to the importance of gender in the overall picture of decreasing numbers in physics, the results of both the present chapter, and the previous chapter that relates to gender differences, will be examined separately in the subsequent chapter.

GENDER DIFFERENCES IN SECONDARY STUDENTS' CONSTRUCTIONS ABOUT BIOLOGY AND PHYSICS

Chapter Six

6.1 INTRODUCTION

It has been shown in Chapter 4 that there is a decline in the general popularity of physics among students, from National Curriculum Year 7 to Year 11, that is, over the period of secondary school. This general trend appears to continue in both A-level and undergraduate students (Chapters 7 and 8). It has also been established that students' interest in physics correlates with their general liking or disliking of it. Thus, it appears that a major factor that underpins students' increasingly negative feelings towards physics is their changing perception of its interest. These conclusions, however, are based on the responses of the overall student population. A number of studies have demonstrated that there are differences in the attitudes of male and female students to academic subjects.

A general trend found in many studies is that girls are less interested in science than are boys (Graig and Ayres, 1988; Weinburg, 1995; Ramsden, 1998) A relatively recent study by Reid and Skryabina (2003) has shown that this is also true of differences in the attitude of males and females specifically to physics. In addition to this there have been many studies which have shown that boys have a greater interest in science than girls, with girls being more interested in the biological or social sciences and boys being more interested in the physical sciences (Clarke, 1972; Mcgriffin 1973).

Differences in attitudes of males and females to biology and physics become apparent in the numbers of males and females who choose to study physics at university level (Harlen, 1993; Stewart, 1998). For example, in 2001 in

England and Wales only 37% of the 10 760 applications for places on physics programmes of study were from females. This was in contrast to applications for biology programmes of study, which not only had more applicants overall (16 000) but also where 70% of the applications were from females (Universities and Colleges Admissions Service [UCAS], 2003). Although there are some exceptions, this under-representation of females in physics appears to be an international problem (Parker, 2002). Furthermore, this problem appears to be resilient, and has not been significantly modified by initiatives, such as the Women into Science and Engineering (WISE) project, specifically designed to bring females into science. Physics, then, is failing to attract a large proportion of its potential constituency, with females tending to opt for biology rather than physics courses.

In order to forestall the development of negative views of physics, in females, it is necessary to have an appreciation of which of the plethora of possible factors have major influences on females' perceptions of physics, and hence on their likelihood of choosing to study physics. This chapter is therefore designed to compare the developing attitudes to physics of girls and boys over the period of secondary schooling. In order to distinguish the degree to which the attitudes revealed are specific to physics or are related to science more generally, students' views about biology have been probed, for comparison.

6.2 METHODS

In order to gain an insight into gender differences in attitudes to physics and biology the data from the cross age study using closed-form questionnaire, as described previously in Chapter 4, were analysed to compare the responses of male and female students. In addition, the data from the combined closed and open form questionnaire completed by year 10 students, as described in chapter 5, were analysed according to students gender.

6.2.1 Data analysis

The design and administration of these questionnaires has been previously described in Chapters 4 and 5.

The students' responses from the closed-form questionnaire were encoded into an SPSS database for statistical analysis. In order to clarify the interpretation of the results, the 'strongly agree' and 'agree' responses were pooled, as were the 'neither agree nor disagree', 'disagree' and 'strongly disagree' responses. For the first two items about general feelings towards biology or physics, the 'really like' and 'like' responses were combined, as were the 'neither like nor dislike, 'dislike' and 'really dislike' responses. For statistical analyses, the responses of Year 7 male and female students were compared using the Chi-square test. The responses of the Year 11 male and female students were compared in the same way. Chi-square analysis was also used to compare the responses of male students in Years 7 and Year 11. The response of female students in Years 7 and 11 were compared in the same way. The responses of sub-sets of students (Year 7 males, Year 7 females, Year 11 males, Year 11 females) to parallel items about biology and physics were compared using a ranking test, the McNemar test. Rotated varimax factor analysis and regression analysis were conducted using the original, 5-response-category data.

In addition the data from the combined open and closed-form questionnaire, as described in Chapter 5 examining what students mean by 'interesting' and 'boring' in relation to physics were further analysed using Chi squared to identify any significant differences in male and female responses.

6.3 RESULTS

6.3.1 Description of the respondent group

The respondent group for the cross-age study is detailed in section **4.2.4** and **4.3.4**. Of the respondents, 52% were male and 49% were female.

The respondent group for the study of year 10 students' concepts of interesting and boring is detailed in section 5.3.1. Of the respondents, 44% were male and 56% were female.

6.3.2 Presentation of results

The results of the cross age study using the closed questionnaire are plotted as graphs in Figures 6.1 through 6.5; the data, together with the results of the statistical analyses, are given Appendices 6.1 to 6.4 at the end of this chapter. In the graphs and appendices, the percentages plotted and shown are the combined percentages of those who affirmed the ideas in the questionnaire items by giving 'strongly agree' or 'agree' responses. In the graphs, the solid lines represent the responses to items about physics, the broken lines show the responses to items about biology; responses from males are indicated with square data points, those from females with circular data points.

Each of the descriptions below is arranged as follows. Firstly, a comparison is made between the views of males and females; where two percentages are given, the first percentage is that for the males, followed by that for the females. Secondly, a comparison of the views of females about biology and physics is made. Results are described as different only when the differences are statistically significant ($p<0.05$).

The results of the study of the views of year 10 students about what is meant by 'interesting' or 'boring' are shown in Figures 6.7 to 6.9

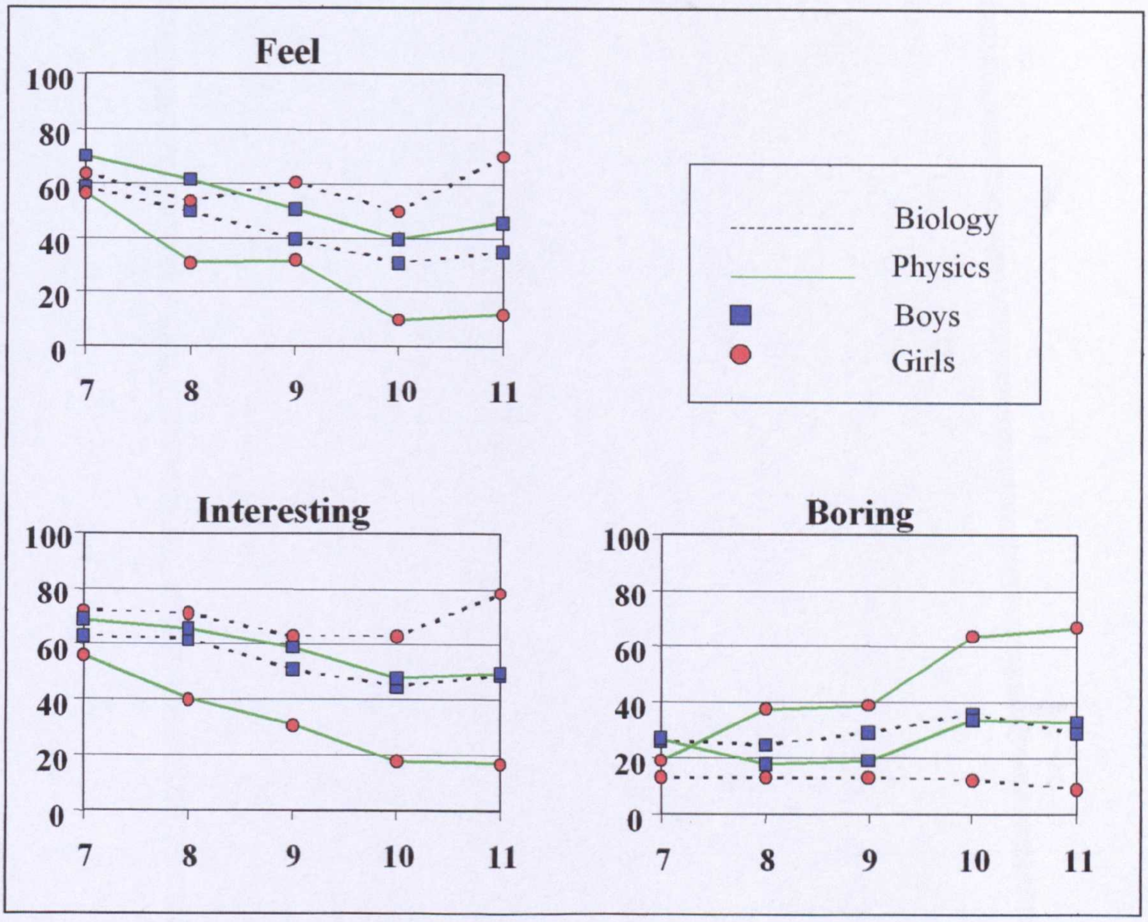
6.3.3 Development of male and female students' constructions of biology and physics

Male and female school students' views about the nature of biology and physics

Already at Year 7 a higher proportion of males than females had positive feelings about physics (70%, 57%) (Figure 6.1). By Year 11, the proportions of students liking physics had declined, but to a greater extent in the females, so that about half of the males liked physics compared with very few females (46%, 12%). In contrast, considerably more Year 11 females liked biology (70%) than physics (12%).

The responses to the questionnaire items about feelings towards biology and physics closely corresponded to the responses about whether biology and physics were perceived as interesting. Here, more Year 7 males than females thought that physics is interesting (69%, 56%). The proportions of students affirming the idea that physics is interesting declined across the year groups, but again more so in the females, so that half of the Year 11 males but considerably fewer of the Year 11 females thought that physics is interesting (50%, 17%). Again, however, more Year 11 females found biology interesting (78%) than found physics interesting (17%).

Figure 6.1 Male and female school students' views about the nature of biology and physics



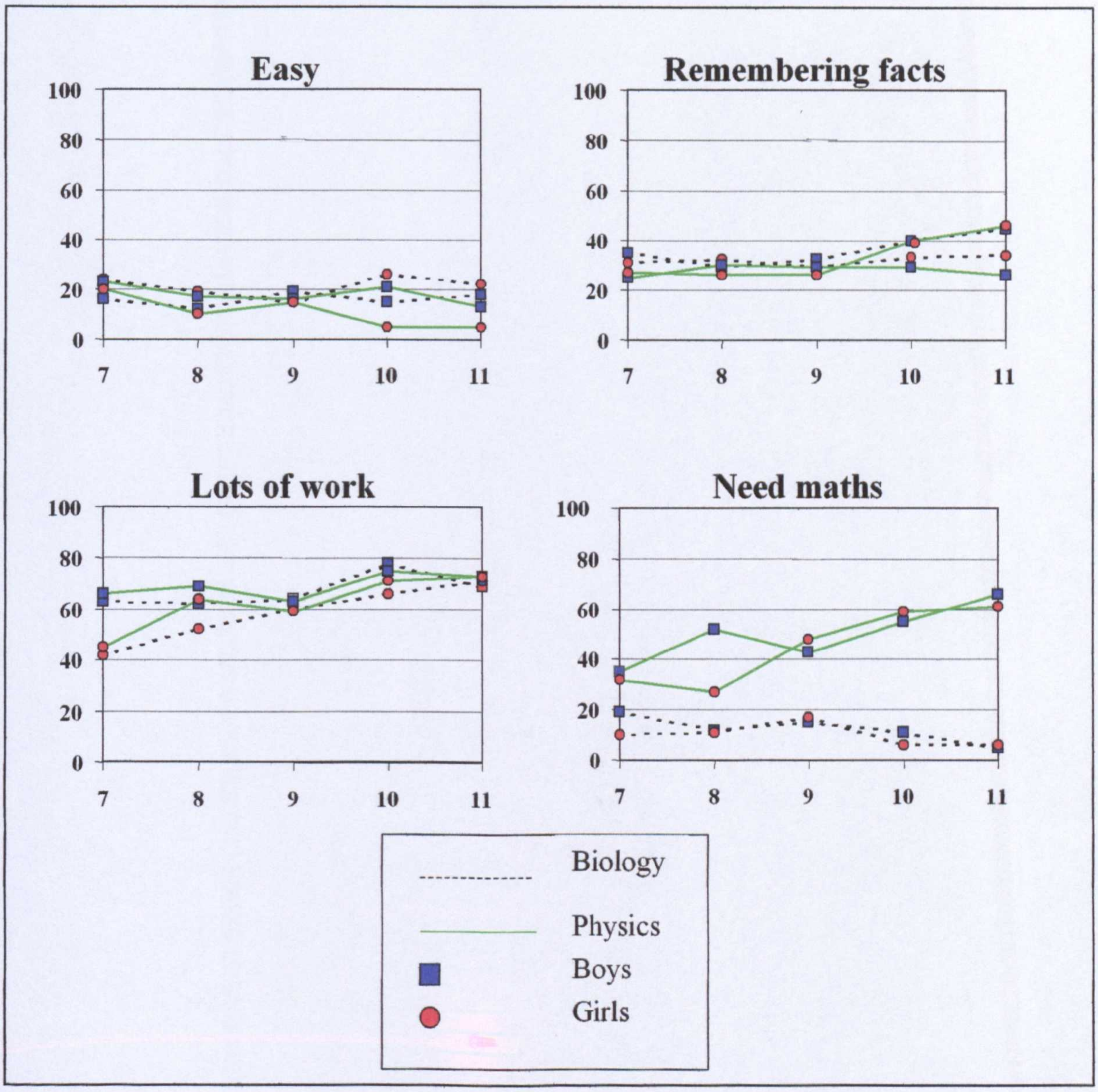
Complementary results were obtained in response to the items about biology and physics being boring, although fewer of the responses were statistically different. Thus, similar proportions of males and females found physics boring in Year 7 (27%, 19%), although the number of females thinking this increased over the year groups so that twice as many females than males in Year 11 found physics boring (33%, 67%). In a complementary manner, fewer Year 11 females found biology boring (9%) than did so for physics (67%).

Male and female school students' views about the academic demands of biology and physics

Less than a quarter of Year 7 students, male or female, thought that physics was easy (23%, 20%)(Figure 6.2). At this stage, students did not appear to distinguish between the difficulty of physics and biology. Over the year groups, however, there was a decrease in the proportions of students finding physics easy, but this decrease was greater in the case of females than males. Thus, by Year 11 fewer females than males reported finding physics easy (13%, 6%). However, more of the Year 11 females – nearly a quarter (23%) – thought of biology as easy.

Trends were seen in the responses to the questionnaire item about the conceptual nature of biology and physics. Thus, similar proportions of male and female Year 7 students thought that physics was about remembering facts (25%, 27%), but the proportions of females thinking this increased over the year groups so that by Year 11 more females than males, nearly half, believed that physics involved factual recall (26%, 46%).

Figure 6.2 Male and female school students' views about the academic demands of biology and physics



In terms of workload, more Year 7 males than females thought that physics required a high workload (67%, 45%). However, the proportion of females thinking this about physics rose over the year groups, so that by Year 11 the responses of the males and females were the same (73%, 73%). Parallel proportions and trends were seem in the responses to the equivalent item about biology, suggesting that this is a property of male and female students' views about science, rather than about physics in particular.

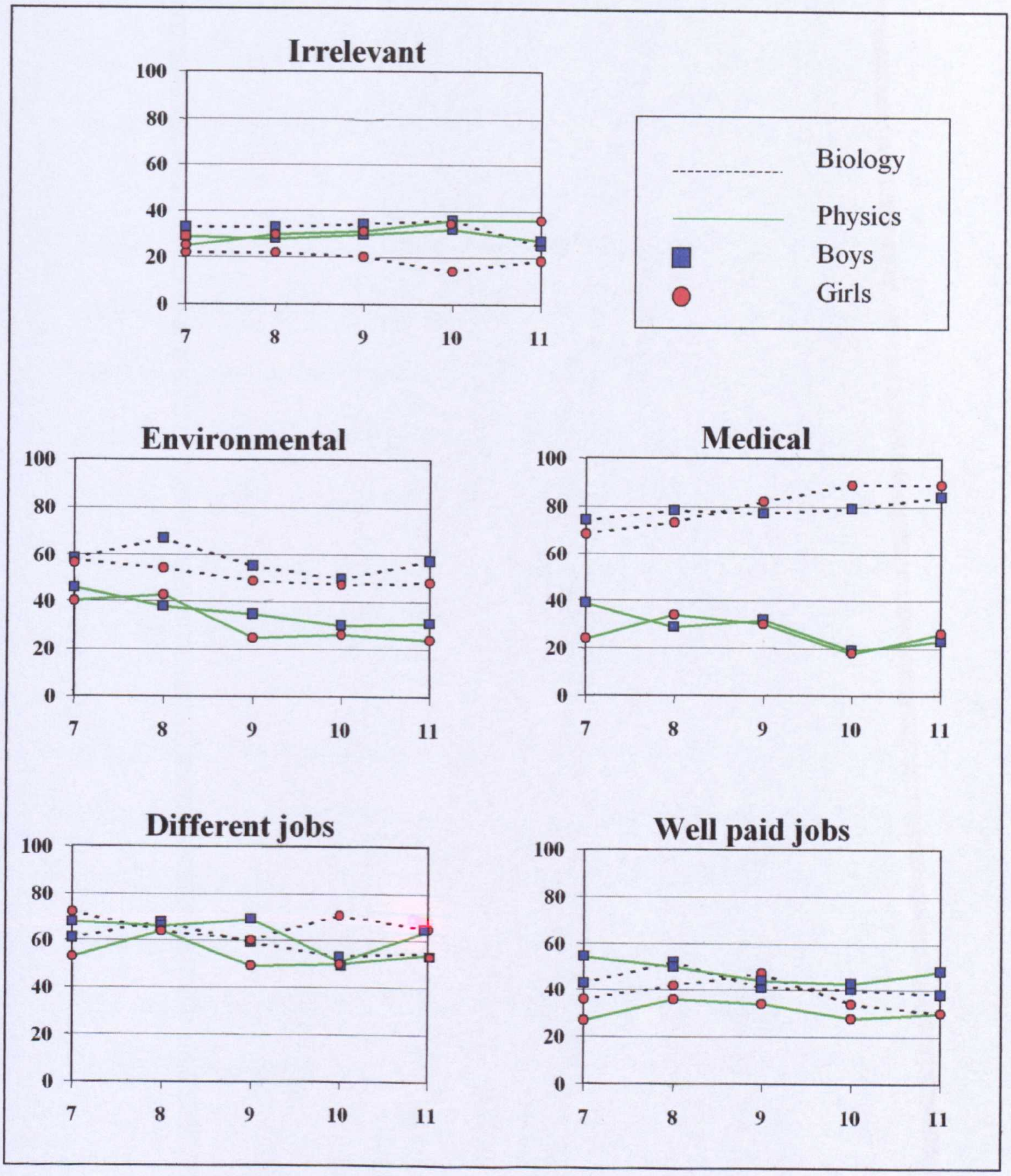
In contrast, both male and female students drew a clear distinction between biology and physics in terms of the need for mathematical ability. In Year 7, similar proportions of males and females thought that physics required a good ability at mathematics (35%, 32%), although fewer thought this true of biology. Over the different year groups the proportions of males and females who thought that physics needed good mathematical ability increased, but to a similar extent, so that by Year 11 the proportions of males and females who thought this were similar (66%, 61%). In Year 11, however, very few of the males or females thought that biology required mathematical ability (5%, 6%).

Male and female school students' views about the relevance and benefits of biology and physics

There were few statistically significant differences between the responses of males and females, between Year 7 and Year 11 students or between the responses about biology and those about physics, to the items about the relevance of these sciences to students' everyday life; from a quarter to about a third of students thought that the subjects were not relevant (Figure 6.3).

When the contributions of biology and physics to more specific, social problems were raised, however, clear differences between the perceptions of the two sciences emerged. For example, although there was no difference in the responses of Year 7 or Year 11 males and females to the idea that physics could contribute to the solution to environmental problems (46%, 40% and 31%, 24%, respectively), in all of these cohorts more students thought biology, rather than physics, could contribute.

Figure 6.3 Male and female school students' views about the relevance and benefits of biology and physics



A broadly similar situation was obtained with the responses to the item about whether the sciences could assist with medical problems. Here, though, more of the Year 7 males than females thought that physics could make a contribution (39%, 24%), although there was no statistically significant difference in the proportions of male and female students holding this view in Year 11 (23%, 26%). However, in all cohorts – Year 7 males and females, and Year 11 males and females – more of the students thought that biology could contribute more than physics.

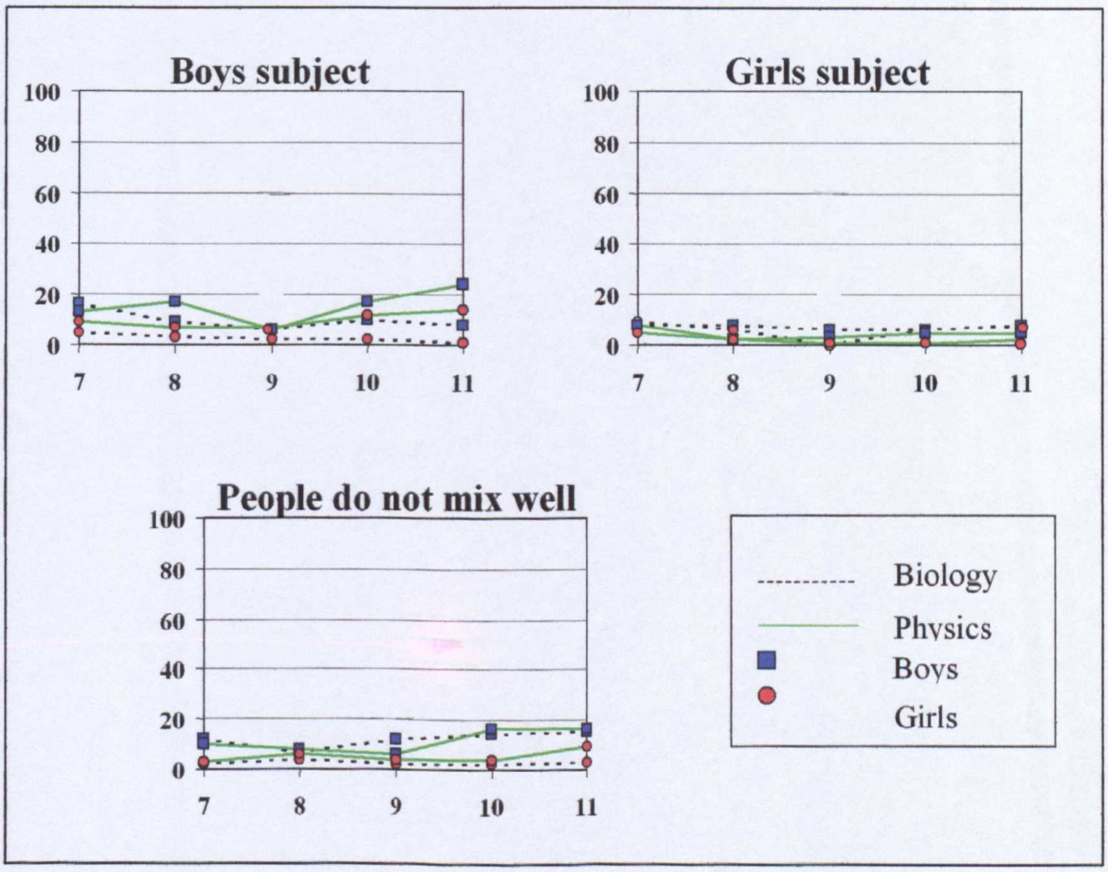
Students' views were also sought about how the sciences might provide more personal, albeit future, benefits in terms of employment prospects. More of the younger group of males than females thought that physics could provide a variety of jobs (68%, 54%), although by Year 11 this gender difference had diminished (64%, 54%). By Year 11, neither the males nor the females distinguished between biology and physics in terms of the potential variety of jobs the subjects offered.

More males also tended to think that physics could provide well-paid employment, and the differences between males and females were more marked in this case. Thus, more males than females in both Year 7 (54%, 27%) and Year 11 (48%, 30%) thought that physics could lead to well paid jobs. However, students in Year 11 did not distinguish between physics and biology in this respect.

Male and female school students' views about the types of people who study of biology and physics

In Year 7, not many of the male or female students thought that physics was especially suited to girls (8%, 5%)(Figure 6.4). Similarly, in Year 11, even fewer of the males and females thought that physics was particularly suitable to girls (5%, 2%).

Figure 6.4 Male and female school students' views about the types of people who study of biology and physics



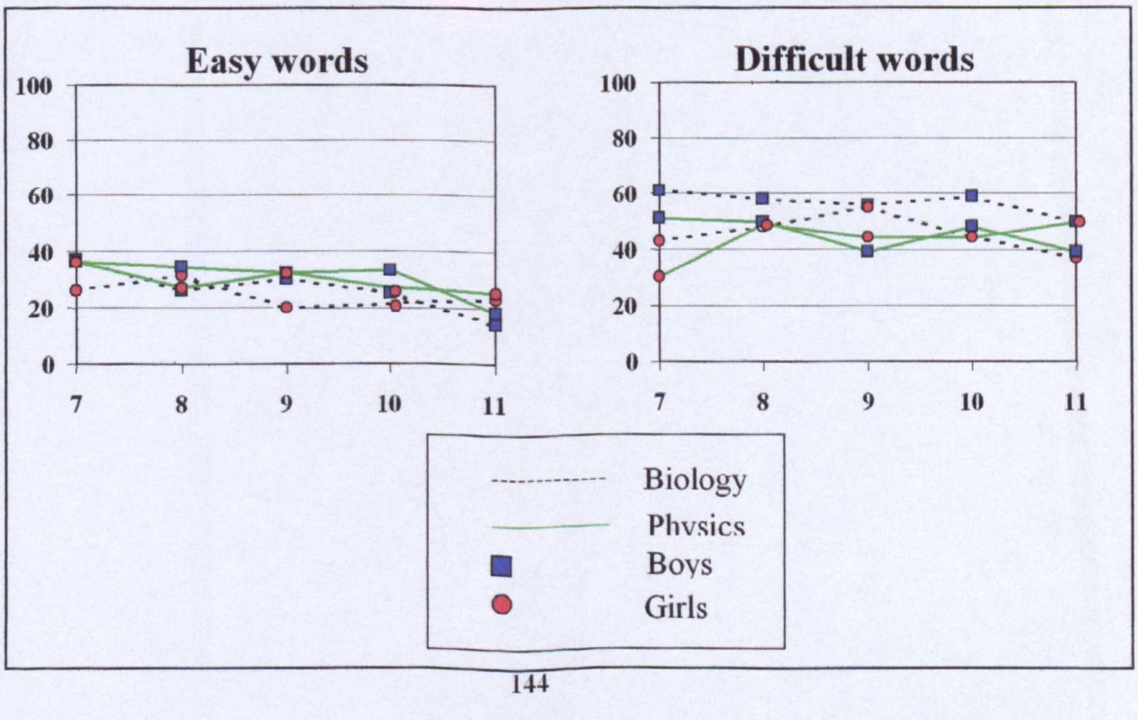
Rather more of the Year 7 students thought that physics was suitable for boys, although there was no difference between the views of the males and females (13%, 9%). By Year 11, however, some gender bias was evident in that more of the males than females thought that physics was a boys subject (24%, 14%).

Relatively few of the Year 7 students thought that people who studied physics did not interact well socially, although more males than females thought this to be true (10%, 3%). In Year 11, however, similar proportions of male and female students thought that people who study physics did not mix well (16%, 9%).

Male and female school students' views about the communication of biology and physics

About a third of both the male and female students in Year 7 thought that physics uses everyday language, but with special meanings (36%, 36%). This idea declined in males across the year groups, although by Year 11 the proportions of males and females holding this view were not statistically significantly different (18%, 25%).

Figure 6.5 Male and female school students' views about the communication of biology and physics



In contrast, more of the younger males than females thought that physics uses difficult, complicated words (51%, 31%), although by Year 11 this gender difference had disappeared (39%, 50%). However, in the Year 11 females, more thought that physics uses difficult words (50%) than thought this of biology (37%).

Summary of male and female school students' views about biology and physics

Thus, it appears that, in general, there were relatively minor differences between the responses of male and female students in Year 7. By Year 11, however, there were clear differences between the responses of males and females to some questionnaire items. The decrease in the proportions of the females who generally liked physics or found it interesting was not matched in their feelings about biology, suggesting that the decline in interest of females was not in science in general, but in specific areas of science. For this reason it was decided to explore further the reasons that might underlie these differences. Firstly, Factor Analysis was used to seek possible themes in male and female students' thinking. Following this, Regression Analysis was employed to explore reasons that might underpin the difference between males' and females' general liking or disliking of physics.

6.3.4 Themes in thinking in Year 11 male and female students

Factor Analysis was used to seek possible cohesive themes in respondents' thinking (Boyes and Stanisstreet, 1993). In order to compare the responses of the males and females, separate Factor Analyses were conducted with Year 11 male students and, separately Year 11 female students using their responses to the questionnaire items that referred to physics (Figure 6.6). Many of the themes revealed were common to male and female students. One such factor contained items about *'Perceptions about the general nature of physics'* – whether or not it was liked, and is interesting or boring, and easy. Another factor common to males and females included the questionnaire items about whether physics is a boys subject, a girls subject, and whether people to like physics do not mix well socially; this factor could be named *'People suitable for physics'*. A further factor was termed *'Social benefits of physics'* because it embraced the two questionnaire items about whether physics could contribute to the social to environmental and medical problems. Finally, both males and females seemed to link the ideas that physics requires factual recall with the notion that it is irrelevant to everyday life although, because there is no immediately obvious link between these two ideas this factor was not named

Other factors, or conceptual themes, appeared different in the Year 11 male and female students. Males, for example, appeared to associate the perceived high workload of physics with employment potential. Females, on the other hand, linked high workload with the idea that physics requires factual recall. Thus, although many of the ways in which Year 11 students think about physics appear common to males and females, there are indications that males and females hold some different conceptual themes about physics.

Reasons that may underpin Year 11 male and female students' attitudes to physics

Further analysis was then undertaken to explore which of the perceived characteristics of physics might influence the different attitudes of Year 11 male and female students to physics and, in particular, lead to its rejection by females. For this, Regression Analysis was performed using the responses to the general item ('Really like' to 'Really dislike' physics) as the dependent variable, and the more specific items as independent variables. For the males, only two of the latter showed statistically significant associations. Males who liked physics tended to view it as interesting and feel that it requires a high level of factual recall. For the female students, more items showed statistically significant associations. Females who disliked physics tended to be those who thought it was boring and, in a complementary manner, not interesting. These students also thought of physics as requiring a high workload, and rejected the notion that physics is easy. Perhaps most interestingly, females who disliked physics also regarded it as irrelevant to their everyday life.

Figure 6.6 Rotated Varimax Factor Analysis of responses of Male and Female Secondary students' responses to items about biology and physic

	Perceived characteristics of physics		*People suitable for physics*		*Social benefits of physics*		*Factual basis and irrelevance*		*Workload and employment*	*Workload and factual recall*
Factor Number	Males (1)	Females (1)	Males (3)	Females (2)	Males (4)	Females (3)	Males (5)	Females (7)	Males	Females
Like physics	842	771								
Physics is interesting	887	793								
Physics is boring	-825	-817								
Physics is easy	559	671								
Physics is about remembering facts				446			537	428		482
Physics needs lots of work									870	864
Physics needs good mathematics										
Physics is irrelevant to everyday life							813	804		
Physics helps environmental problems					616	803				
Physics helps medical problems					843	710				
Physics leads to lots of different jobs	416								488	
Physics leads to well-paid jobs										
Physics is a boys subject	356		688	827						
Physics is a girls subject			693	773						
Physics people do not mix well	-404		622	620						
Physics uses difficult words		-366						393		
Physic uses everyday words										

6.3.5 Differences between reasons of male and females students for finding physics boring or interesting

In Addition to the analysis in terms of student gender of the closed form questionnaire described in chapter 4, the results of the closed and open form questionnaire described in chapter 5 were also analysed to compare responses of year 10 male and female students. This later questionnaire has been designed to evoke the reasons which might underpin students perceptions of physics as being 'boring' or 'interesting'.

Responses to the closed items on this combined questionnaire confirmed that there were differences in the overall feelings about physics of male and female school students (Figure 6.5).

Figure 6.5 Proportions of Year 10 school students finding biology and physics interesting or boring

	Biology			Physics		
	All %	Males %	Females %	All %	Males %	Females %
Very interesting	10	7	12	6	8	4
Interesting	47	45	48	20	28	10
Neither interesting or boring	22	21	23	26	26	25
Boring	15	18	12	25	20	29
Very boring	6	8	5	24	18	20

There was no significant difference in the responses of the males and females to the closed-form item about biology, whereas statistically significantly fewer females than males thought that physics was interesting (36%,17%, $p< 0.001$). Thus, the results to this section of the questionnaire support the contention that students find physics less interesting than a comparator science subject, biology, and that fewer girls than boys find physics interesting.

To further understand why many males and females think of physics in this way, or in other words the where this negative view of physics is being generated, the reasons given by males and females for finding physics boring and interesting were compared (Figures 6.5 and 67). More of the reported females found physics boring because it was seen as too easy, because they disliked specific areas of the curriculum, or because it was seen as irrelevant. More of the males reported that they found physics boring because it was repetitive or because there was too little practical work (Figure 6.6).

Figure 6.6 Differences between reasons of male and females students for finding physics boring.

Reasons for finding physics boring	Boring (%)			
	All	Males	Females	p
Difficult/ hard subject	48	42	51	ns
Subject too easy	11	4	16	0.05
Do not enjoy subject	30	25	32	ns
Content of subject	20	10	25	0.05
Too little practical work	7	14	3	0.005
Subject repetitive/ predictable	6	14	2	0.05
Subject irrelevant	14	6	19	0.05

Figures are given as a percentage of those thinking that physics was very boring or boring, in responses to the closed questionnaire item. p is the probability that any differences between groups in the table might have happened by chance. 'ns' means that the difference is deemed to be 'not significant' (statistically).

The only statistically significance between the males' and females' reasons for finding physics interesting was that more of the males enjoyed the practical exercises (Figure 6.7)

Figure 6.7 Differences between reasons of male and females students for finding physics interesting.

Reasons for finding physics interesting	Interesting (%)			
	All	Males	Females	p
Easy subject	14	12	17	ns
Enjoy subject	10	10	11	ns
Subject offers a challenge	9	6	14	ns
Content of subject	40	40	39	ns
Practical exercises	46	56	29	0.05
Relevance of subject	19	14	29	ns
Variety of subject	12	14	7	ns

Figures are given as a percentage of those thinking that physics was very interesting or interesting, in responses to the closed questionnaire item. p is the probability that any differences between groups in the table might have happened by chance. 'ns' means that the difference is deemed to be 'not significant' (statistically)

6.4 DISCUSSION

6.4.1 Differences in attitudes of male and female students across secondary school to physics

The present section of the study indicates the ways in which the views of male and female students might develop in a differential manner, although it is a cross-age study and therefore does not track the changing opinions of individual students. In the case of a few of the individual ideas probed by questionnaire items, there were differences between the opinions of the youngest males and females studied, but these had disappeared by Year 11. For example, more of the Year 7 males than females thought that physics offers solutions to medical problems, although this gender difference was not apparent in Year 11. Occasionally the opposite situation obtained, with differences between the views of males and females being generated over the period of secondary schooling. For instance, by Year 11 more males than females (although still rather few) thought that physics is easy although no significant difference between the genders had existed at Year 7. More frequently, differences between the views of males and females that did already exist in the youngest students had become exacerbated by end of secondary schooling. For example, although more of the younger males than females liked physics and found it interesting, these gender differentials were considerably greater by Year 11. The general picture, then, is one of males either retaining their relatively positive views about physics across the period of secondary schooling, or at least losing such attitudes slower than females (Reid and Skryabina, 2003). Furthermore, not only do females develop more negative views about physics than their male counterparts, they also develop or retain more positive opinions about biology. So by Year 11, amongst the females, biology, compared with physics, is liked more, and viewed as more interesting (and less boring), easier, less mathematically demanding, more relevant, and more able to contribute to solutions to environmental and medical problems. Thus, females in Year 11, at a time when they are selecting A-level subjects with a view, in some cases, to plan their university courses, are harbouring a series of negative views about physics, together with a preferential view of biology.

6.4.2 Differences in attitudes of male and female students in Year 11 about physics

Given the critical nature of the situation at Year 11 in terms of students' future selection of A-levels, degree programme and even future employment (Harding and Parker, 1995), it is worth considering further the differences in the views of males and females at this stage. It is clear that fewer females than males like physics at the end of secondary schooling. The present section of the study revealed some overt reasons for this. Fewer of the females than males thought physics was interesting; more thought it was boring. Fewer of the females also thought that physics was easy. This is important because perception of a subject as difficult may lead to the development of negative attitudes about it (Rennie and Punch, 1991), and there are reasons why this might apply particularly to females. In general, males tend to need to establish only an internal coherence to believe that they understand a particular concept, whereas females are not convinced of their comprehension until that can locate the same concept in a broader context (Stadler, Duit and Benke, 2000). Thus, females may be making a harsher judgement of their level of understanding, and hence rate physics as more difficult than do males. Fewer of the females also thought that physics would lead to well-paid employment, as this might be a factor in females seeing physics as less 'personally' valuable, and being less inclined to pursue physics as a career.

In some cases, there were no differences in the overt opinions of Year 11 females and males about physics. Even here, however, there is the possibility of covert gender differentiation, because the perceived characteristic or quality of physics being considered might be more, or less, valued by females. For example, although there was no difference in the proportion of Year 11 males and females thinking that physics required mathematical ability, females may be more intimidated by this than are males. Again, similar proportions of Year 11 males and females regarded physics as irrelevant to their everyday lives. More specifically, there were no differences in the proportions of females or males who thought that physics could contribute to solutions to environmental and medical problems. This opinion, however, is likely to have differential consequences in males and females, since there is evidence that females value the relevance of a subject (Woolnough, 1994) more than males do. So, whereas male students show more affinity with abstraction, females prefer a contextual approach supported by concrete examples (Murphy, 1990; Qualter, 1993). This is supported by the results from the present section of this study, which showed that, in the case of females, there was an association between disliking physics and thinking that it is 'irrelevant'.

6.4.3 Differences in the views of male and female students in Year 10 about why physics is interesting

One important factor associated with a general liking (or disliking) of physics in Year 11 students was the opinion that it was interesting (or not). Although this applied to both males and females, the reasons underpinning this linkage differed to some extent between males and females. Students may use words such as 'interesting' or its antonym, 'boring', in over-generalised, even idiosyncratic ways. In the previous chapter an exploration of what Year 10 students mean by these terms in the context of physics and biology indicated that a number of ideas underlie these opinions. Both male and female students report that one reason that they find biology interesting but physics boring is because of the curriculum contents of the subjects. It was found that more girls found physics boring because they disliked specific areas of the curriculum, or because it was seen as irrelevant to them and more males found physics interesting because they enjoyed the practical exercises. This supports the findings of previous research, in which the content of the curriculum favoured boys more than girls with physics often being taught in an abstract rule dominated way with practical work which is more suited to boys than girls (Murphy, 1990). Instead, it was suggested that girls would react more favourably to teaching that includes examples that are more concrete and related to human activity and experience, and would benefit from a more contextual approach to teaching (Qualter, 1993).

Interestingly, the general unpopularity of physics is not found in situations in which the syllabus is application-led, for example in the Netherlands (Stokking, 2000) or Scotland (Reid and Skryabina, 2002, 2003). The role of the curriculum and possible approaches to addressing it in terms of male and female differences will be further explored in the final chapter.

Surprisingly, the results showed that girls and boys don't perceive the subject as sexist. It may be that they do not decide to follow the subject because they think that the subject is boy or girl based, but rather they make a decision based on certain factors that they like and dislike about the subject, which happen to be trends prevalent in groups of girls' or boys' thinking.

The previous Chapters 4 and 5 and this current chapter have examined the attitudes of students to physics and biology and how these attitudes have developed over the course of secondary schooling. However, the problem extends further than this, into A-levels and beyond. For this reason, the next chapter examines the attitudes of students taking A-level biology, physics and, as a comparator English, to find out how their attitudes towards physics and biology differ.

Appendix 6.1

Distribution of responses of male and female school students to questionnaire items about the nature of biology and physics

Appendix 6.1 Distribution of responses of male and female school students to questionnaire items about the nature of biology and physics

	Year 7 Students			Males	Females	Year 11 students		
	Males (% affirm)	Males vv Females p (Chi^2)	**Females** (% affirm)	Year 7 vv Year 11 p (Chi^2)	Year 7 vv Year 11 p (Chi^2)	**Males** (% affirm)	Males vv Females p (Chi^2)	**Females** (% affirm)
Like biology	**59**	Ns	**64**	0.001	Ns	**35**	0.001	**70**
Biology vv Physics p (McNemar)	0.05		Ns			Ns		0.001
Like physics	**70**	0.05	**57**	0.001	0.001	**46**	0.001	**12**
Biology is interesting	**63**	Ns	**72**	0.05	Ns	**49**	0.001	**78**
Biology vv Physics p (McNemar)	Ns		0.005			Ns		0.001
Physics is interesting	**69**	0.05	**56**	0.001	0.001	**50**	0.001	**17**
Biology is boring	**26**	0.01	**13**	Ns	Ns	**29**	0.001	**9**
Biology vv Physics p (McNemar)	Ns		Ns			Ns		0.001
Physics is boring	**27**	Ns	**19**	Ns	0.001	**33**	0.001	**67**

The percentages show the proportion of school students in who affirmed the idea, giving either 'I strongly agree' or 'I agree' responses

Appendix 6.2

Distribution of responses of male and female school students to questionnaire items about the academic demands of biology and physics

Appendix 6.2 Distribution of responses of male and female school students to questionnaire items about the academic demands of biology and physics

	Year 7 Students			Males	Females	Year 11 students		
	Males (% affirm)	Males vv Females p (Chi^2)	**Females** (% affirm)	Year 7 vv Year 11 p (Chi^2)	Year 7 vv Year 11 p (Chi^2)	**Males** (% affirm)	Males vv Females p (Chi^2)	**Females** (% affirm)
Biology is easy	**16**	ns	**24**	ns	ns	**18**	ns	**23**
Biology vv Physics p (McNemar)	ns		ns			Ns		0.001
Physics is easy	**23**	ns	**20**	0.05	0.001	**13**	0.05	**6**
Biology is bout remembering facts	**35**	ns	**31**	ns	ns	**45**	ns	**34**
Biology vv Physics p (McNemar)	0.05		ns			0.005		ns
Physics is about remembering facts	**25**	ns	**27**	ns	0.005	**26**	0.001	**46**
Biology needs lots of work	**64**	0.001	**42**	ns	0.001	**70**	ns	**71**
Biology vv Physics p (McNemar)	ns		ns			Ns		ns
Physics needs lots of work	**67**	0.001	**45**	ns	0.001	**73**	ns	**73**
Biology needs good mathematics	**19**	0.05	**10**	0.001	ns	**5**	ns	**6**
Biology vv Physics p (McNemar)	0.001		0.01			0.001		0.001
Physics needs good mathematics	**35**	ns	**32**	0.001	0.001	**66**	ns	**61**

The percentages show the proportion of school students in who affirmed the idea, giving either ‘I strongly agree’ or ‘I agree’ responses

Appendix 6.3

Distribution of responses of male and female school students to questionnaire items about the academic demands of biology and physics

Appendix 6.3 Distribution of responses of male and female school students to questionnaire items about the academic demands of biology and physics

	Year 7 students			Males	Females	Year 11 students		
	Males (% affirm)	Males vv Females p (Chi²)	**Females** (% affirm)	Year 7 vv Year 11 p (Chi²)	Year 7 vv Year 11 p (Chi²)	**Males** (% affirm)	Males vv Females p (Chi²)	**Females** (% affirm)
Biology is irrelevant to everyday life	33	0.05	22	ns	ns	25	ns	19
Biology vv Physics p (McNemar)	ns		ns			ns		0.005
Physics is irrelevant to everyday life	29	ns	25	ns	ns	27	ns	36
Biology helps environmental problems	58	ns	57	ns	ns	57	ns	48
Biology vv Physics p (McNemar)	0.05		0.005			0.001		0.001
Physics helps environmental problems	46	ns	40	0.01	0.01	31	ns	24
Biology helps medical problems	74	ns	68	0.05	0.001	84	ns	89
Biology vv Physics p (McNemar)	0.001		0.001			0.001		0.001
Physics helps medical problems	39	0.01	24	0.005	ns	23	ns	26
Biology leads to lots of different jobs	61	ns	72	ns	ns	55	ns	65
Biology vv Physics p (McNemar)	ns		0.001			ns		ns
Physics leads to lots of different jobs	68	0.01	54	ns	ns	64	ns	54
Biology leads to well-paid jobs	43	ns	36	ns	ns	38	ns	30
Biology vv Physics p (McNemar)	0.01		0.05			ns		ns
Physics leads to well-paid jobs	54	0.001	27	ns	ns	48	0.005	30

The percentages show the proportion of school students in who affirmed the idea, giving either 'I strongly agree' or 'I agree' responses

Appendix 6.4

Distribution of responses of male and female school students to questionnaire items about the types of people who study biology and physics

Appendix 6.4 Distribution of responses of male and female school students to questionnaire items about the types of people who study biology and physics

	Year 7 students			Males	Females	Year 11 students		
	Males (% affirm)	Males vv Females p (Chi^2)	**Females** (% affirm)	Year 7 vv Year 11 p (Chi^2)	Year 7 vv Year 11 p (Chi^2)	**Males** (% affirm)	Males vv Females p (Chi^2)	**Females** (% affirm)
Biology is a boys subject	**16**	0.005	**5**	0.05	-	**8**	0.01	**1**
Biology vv Physics p (McNemar)	ns		ns			0.001		0.001
Physics is a boys subject	**13**	ns	**9**	0.05	ns	**24**	0.05	**14**
Biology is a girls subject	**8**	ns	**9**	ns	ns	**8**	ns	**7**
Biology vv Physics p (McNemar)	ns		ns			ns		0.05
Physics is a girls subject	**8**	ns	**5**	ns	-	**5**	ns	**2**
Biology people do not mix well	**12**	0.005	**2**	ns	-	**15**	0.001	**3**
Biology vv Physics p (McNemar)	ns		ns			ns		ns
Physics people do not mix well	**10**	0.05	**3**	ns	ns	**16**	ns	**9**

The percentages show the proportion of school students in who affirmed the idea, giving either 'I strongly agree' or 'I agree' responses

Appendix 6.5

Distribution of responses of male and female school students to questionnaire items about the communication of biology and physics

Appendix 6.5 Distribution of responses of male and female school students to questionnaire items about the communication of biology and physics

	Year 7 students			**Males**	**Females**	**Year 11 students**		
	Males (% affirm)	Males vv Females p (Chi^2)	**Females** (% affirm)	Year 7 vv Year 11 p (Chi^2)	Year 7 vv Year 11 p (Chi^2)	**Males** (% affirm)	Males vv Females p (Chi^2)	**Females** (% affirm)
Biology uses everyday words	**37**	0.05	**26**	0.001	ns	**14**	ns	**23**
Biology vv Physics p (McNemar)	ns		ns			ns		ns
Physics uses everyday words	**36**	ns	**36**	0.001	ns	**18**	ns	**25**
Biology uses difficult words	**61**	0.005	**43**	ns	ns	**50**	0.05	**37**
Biology vv Physics p (McNemar)	0.05		0.05			ns		0.05
Physics uses difficult words	**51**	0.001	**31**	0.05	0.005	**39**	ns	**50**

The percentages show the proportion of school students in who affirmed the idea, giving either 'I strongly agree' or 'I agree' responses.

A-LEVEL STUDENTS' CONSTRUCTIONS OF BIOLOGY AND PHYSICS

Chapter Seven

7.1 INTRODUCTION

Below the age of 16, all school students in England and Wales take a general course in science education, rather than selected lessons in physics, biology and/or chemistry. In Chapters 4,5 and 6, the issues relating to 11-16 years olds' attitudes to physics and biology have been identified and discussed. It has been clearly shown that over the period of secondary schooling, many students develop a negative attitude to physics, particularly in Years 10 and 11. It has also been established that there are differences in the opinions of males and females about biology and physics. However, a lot of general discussion centres on the decline in the numbers of students studying the science after GCSE level. The aim of the present chapter is to explore the attitudes of A-level students to physics in the hope of identifying factors that have influenced the students in making their subject choice.

7.1.1 Numbers of students taking A-level sciences

Much educational research has looked into the opinions of school students in terms of their attitudes to science (Young, 1993; Barber, 1993; Sheldrake, 1994; House of Commons, 2002). This research has identified a decline in attitudes to science over the course of secondary schooling. Rather fewer studies have explored students' attitudes to specific sciences, such as physics. It has been thought that making science compulsory up to National Curriculum Year 11 would have the effect of preventing students from dropping science. This strategy, however, has not had the desired effect. So, many able students are continuing to drop science at the earliest opportunity. In other words, when students are able to make a choice of subjects at A-level, many do not choose science so that the numbers of students going on to study science at A-level is far below that of other subjects like English and social sciences (Harvard, 1996). Even within the science subjects physics is suffering, with the number of students gaining physics A-level between 1980 and 1993 falling from 35 000 to about 28 400 (Department for Education and Employment, 1994). The number of students following the physical sciences (physics and chemistry) at A-level and undergraduate level in comparison to the biological sciences differs greatly, with substantially more following the biological sciences (Figure 7.1).

Figure 7.1 Numbers of students taking Biology and Physics at 'A' level and in Higher Education, 2002

	Biological sciences			Physical sciences		
	Total	**Males**	**Females**	**Total**	**Males**	**Females**
Numbers taking 'A' level	52 132	21 2988	30 144	31 543	25 167	6 376
Total full-time undergraduates	26 412	9 832	16 280	13 414	8 006	5 408

7.1.2 Possible reasons why few students choose science

Various factors might be responsible for influencing students' choice of A-level subject. One reason why not every 16 year old chooses physics is, of course, that not all are intrinsically interested in science. Some want to learn another language; others want to study the arts. In addition, peer pressure may play a role in that a student may not wish to take a subject that will not be taken by their contemporaries (Brown, 2001). Furthermore many teenagers are under pressure from their parents to study subjects like computing, which is seen as a, 'subject of the future', perhaps with good employment prospects. Other factors highlighted as influences have included choice of career and school effectiveness in producing scientists (Woolnough 1997). Hofstein and Kempa (1985) looked at the effect of different teaching styles and strategies and found that they too play an influential role student's choices

Others have suggested that the problem lies with the combined science course, because it may not be easy for pupils to differentiate between physics and other sciences and, even if they do, they might regard physics as a difficult subject that needs mathematical ability (Brown, 2001). In a similar way, there have been doubts raised about the ability of students to cope with A-level after taking a double award GCSE science (Sears, 1993). Osborne, Driver and Simon (1998) have suggested *"Physics and Mathematics at [School] are only taken by students who do well and are not taken as incidental or additional subjects"*. In other words, students' performance at GCSE may be a major factor. Backhouse, Dickins, Rayner and Wood (1982) suggested that success in mathematics and science influences the uptake at A-level. Physics appears to most pupils, as the lesser part of a single subject – "*physicsandmaths*" – that takes up two of the three normal choices as A-level. This idea is supported by the number of students who choose science subjects that are perceived as much less attached to mathematics, such as biology and geography. In these subjects student numbers are burgeoning (Brown, 2001).

7.1.3 Students' constructions of physics

In order to begin to address the problem of the unpopularity of physics we need further insight into why students are dissuaded from this subject. The present section of this research sought to explore the attitudes of students taking A-level Biology, Physics and English, to the sciences. It was designed to try to clarify the role of a variety of factors that might have been influential in students' choices. Understanding the views of those who have indeed taken up A-level sciences is important if we hope to increase the number of pupils taking science with a view to working in such careers. In addition, the views of those who have chosen not to follow the science A-levels are of equal importance to gain clues about why students are deterred from taking A-level physics. Here the views of AS-level students are explored; these are the students who have most recently elected to study certain subjects beyond GCSE level.

7.2 METHODS

7.2.1 Questionnaire design and administration

In order to gain an insight into AS-level students' attitudes towards physics and biology a closed form questionnaire was used. In this study, AS-level students' views about biology and physics were explored using a closed-form questionnaire. This was similar to the questionnaire used to explore the ideas of secondary school students in Chapter 4. It used the same 16 closed-form items for physics and biology (see Figure 4.4). The coversheet was modified to make it suitable for AS-level, rather than school students. This questionnaire was piloted with 85 AS level students (40% male, 60% female). Examination of the responses and informal conversations with the respondents suggested that the wording of the questionnaire items was suitable.

The final questionnaire was arranged in three sections. The coversheet asked students to confirm their year or class, their age, gender and GCSE grades for science, maths and English. The questionnaire also asked the students to state which subjects they were studying at AS-level (Figure 7.2).

In addition, the coversheet contained two items asking students about their general feelings about biology and physics. The responses available for these two items, illustrated by the physics item, were 'I really like physics, 'I quite like physics', 'I neither like nor dislike physics, 'I don't like physics much' and 'I really don't like physics'.

Figure 7.1 A-level questionnaire coversheet

What do you think about your science subjects?

We are doing a research project into what students think about some of the different subjects in science, like Biology and Physics. We would like to know your opinion.

About you

Your age………….. Your year/class……….. Male/Female…………

What **GCSE** grades did you obtain in….

Science? ………….
English? …………..
Maths? ……………

What **AS levels** are you taking?

1 ………………………… 4 ………………………
2 ………………………… 5 ………………………
3 …………………………

What do you feel about **Biology**?

☐	☐	☐	☐	☐
I really like Biology	I quite like Biology	I neither like nor dislike Biology	I don't like Biology much	I really don't like Biology

What do you feel about **Physics**?

☐	☐	☐	☐	☐
I really like Physics	I quite like Physics	I neither like nor dislike Physics	I don't like Biology Physics	I really don't like Physics

The other two sections of the questionnaire employed a 5-point Likert scale to explore the students' attitudes to 16 items about physics and, on a separate page, 16 parallel items about biology. Although the questions are grouped under themes in the Results section, they were in random order on the actual questionnaire. Two versions of the questionnaire were produced to neutralise any 'carry over' effect. In one version of the questionnaire, the items about physics appeared before those about biology; in the other version of the questionnaire this order was reversed.

Sixth-form colleges were identified using a NorthWest Sixth form college database. They were randomly selected and contacted by letter; the letters were followed up by telephone. Colleges were assured that the questionnaires were anonymous and that respondents could not be identified. Of those contacted, seven colleges agreed to take part.

During the administration of the questionnaires, the two versions were distributed alternately to students. The two versions of the questionnaire were produced on different colour paper, to facilitate separation of the completed questionnaires before encoding. The researcher was not present when the questionnaires were completed because class times of English, biology and physics lessons differed within the colleges. The class teachers administered the questionnaires in the lessons. In order to ensure consistency teachers were provided with guidelines about how to administer the questionnaires (Appendix 7.2).

7.2.3 Analysis of questionnaire responses

The students' responses were encoded into a SPSS datasheet. The frequencies of the different responses were determined for each questionnaire item. In order to compare the responses of different sub sets of students, chi-square analysis was used to compare the responses of students doing different subjects to individual questionnaire items. For chi-square analyses, to clarify the interpretation of the statistical tests, the 'strongly agree' and 'agree' responses were combined, to give the proportion of students who affirmed the idea. Similarly, the 'neither agree nor disagree', 'disagree' and 'strongly disagree' responses were combined. The responses to parallel items in physics and biology were also compared using the non-parametric Wilcox Ranking test. This was done for students within each subject group.

Factor Analysis was employed using the original 5-response category data, to expose possible links between questionnaire items and so reveal possible themes in students' thinking. Finally, regression analysis was used (again with the original 5-response category data) to explore which of the items about individual characteristics of the biology and physics might correspond to the general items concerning feeling ('liking' or 'disliking') for the subjects.

7.3 RESULTS

7.3.1 Description of the respondent group

Originally, 529 AS-level students from seven community colleges were given the questionnaire. The age range of the students was from 16 to 33 years. In order to introduce some homogeneity into the sample in terms of previous experience, the responses of students aged 21 and above (or those who did not provide their age) were removed from the data set. In a few cases, students had not fully completed the questionnaire; the responses of these students were also removed from the data set. This left 491 students. Three cohorts of students were then constructed, those doing AS-level biology but not physics or English (n=128), those doing AS-level Physics but not biology or English (n=90) and those doing AS-level English but not biology or physics (n=178). The remaining students were doing two or more of these AS-levels; their responses were removed from the data set.

7.3.2 Overview of analysis

The percentages of students affirming each statement ('strongly agree' plus 'agree' responses) are shown in figure 7.3, as are the p values determined by the Wilcoxon ranking test to indicate statistically significant differences between the responses to parallel questionnaire items about biology and physics. The questionnaire items have been arranged in themes, although the order within the actual questionnaire was random. In the descriptions below, two values are given in parentheses. The first value is the percentage of students affirming the statement for the biology item; the second is for those affirming the parallel physics item.

7.3.3 Views of students taking AS-level Biology

Nature of the subjects

The first cohort of students considered here consists of those who were taking AS-level biology, but not physics or English. The majority of these students liked their subject, whereas few liked physics (84%, 17%). In a parallel manner, most of the AS-level Biology students found biology, but not physics, interesting (86%, 29%, $p<0.001$). In a complementary manner, few of the AS-level Biology students found biology boring, whereas about half thought of physics as boring (4%, 52%, $p<0.001$).

Academic demands of the subjects

In terms of the academic demands of the two subjects, only a fifth of the biology students thought that their subject was easy, but even fewer thought that physics would be easy (20%, 4%, $p<0.001$). Similar proportions of students, between about a quarter and a fifth, thought that biology and physics demanded factual recall rather than conceptual comprehension (27%, 20%). The majority of the biologists saw both subjects as requiring a high workload, although more so in the case of their own subject, biology, than physics (85%, 73%, $p<0.05$). Few of the AS-level Biology students perceived the study of biology as requiring good mathematical abilities, whereas most of them thought this true of physics (8%, 87%, $p<0.001$).

Relevance and benefits of the subjects

Few of the AS-level Biology students thought that their subject was irrelevant to daily life, although more thought this true of physics (13%, 28%). This differential perception of biology and physics was supported to specific examples. So, many more of the Biology students thought that biology could contribute to the solution of environmental problems than could physics (54%, 20%, $p<0.001$). A similar situation obtained with the responses to the questionnaire item about the potential contribution of the subjects to medical problems, with the vast majority thinking this true of biology, but only about a third believing this of physics (91%, 36%, $p<0.001$). In terms of more personal benefits, more of the Biology students thought that biology, as opposed to physics, would lead to a variety of employment opportunities (86%, 66%). In contrast, more of these students thought that physics, compared with biology, could lead to well-paid jobs.

Types of people

Very few of the AS-level Biology students thought that their subject was more suited to males, although more than a quarter thought this of physics (3%, 27%, $p<0.001$). A few thought that biology was especially appropriate for females, and none thought this about physics (7%, 0%, $p<0.01$). A few of the Biology students did think that physicists lacked social skills (1%, 12%, $p<0.001$).

Communication of the subjects

The same proportions of AS-level Biology students thought that biology and physics used difficult, complicated vocabulary (48%, 48%). In a complementary manner, few thought that the subjects used easy, everyday words, although more thought this true for physics (14%, 21%, $p<0.05$).

7.3.4 Views of students taking AS-level Physics

Nature of the subjects

The second cohort of students consisted of those who were taking AS-level Physics, but not biology or English. Most of these students liked physics, although far fewer liked biology (21%, 81%, $p<0.001$). In a parallel manner, most of the students thought that physics, but not biology, was interesting (40%, 84%, $p<0.001$). Similarly, more of the Physics students considered biology, rather than their own subject, boring (41%, 16%, $p<0.001$).

Figure 7.3 Views of AS-level Biology, Physics and English students to biology and physic

	Biology AS-level students (n=128, 38%=male, 63%=female)			Physics AS-level students (n=90, 88%=male, 12%=female)			English AS-level students (n=178, 31%=male, 70%=female)		
	Views about *Biology* (%)	p	Views about Physics (%)	Views about *Biology* (%)	p	Views about Physics (%)	Views about *Biology* (%)	p	Views about Physics (%)
General nature of subject									
Like	84	0.001	17	21	0.001	81	39	0.001	12
Interesting	86	0.001	29	40	0.001	84	60	0.001	23
Boring	4	0.001	52	41	0.001	16	23	0.001	64
Academic demands of subjects									
Easy	20	0.001	4	26	0.001	16	12	0.001	4
Factual recall	27	Ns	20	49	0.001	17	34	Ns	28
Lots of work	85	0.05	73	57	0.01	77	60	0.05	73
Need to good at maths	8	0.001	87	4	0.001	89	8	0.001	77
Relevance and benefits of subjects									
Irrelevant	13	0.001	28	21	0.05	14	14	0.001	34
Help environmental problems	54	0.001	20	67	0.001	32	52	0.001	24
Help medical problems	91	0.001	36	97	0.001	53	90	0.001	27
Lots of jobs	86	0.005	66	61	0.001	92	66	0.05	53
Well-paid jobs	35	0.05	46	32	0.001	68	34	Ns	38
Types of people who like subject									
Boys subject	3	0.001	27	1	0.001	26	2	0.001	14
Girls subject	7	0.01	0	14	0.001	2	5	0.01	1
Don't mix well	1	0.001	12	8	Ns	13	1	0.001	5
Communication of subject									
Difficult, complicated words	48	Ns	48	50	Ns	43	43	Ns	51
Easy, everyday words	14	0.05	21	9	0.005	23	20	Ns	14

Academic demands of the subjects

Neither biology nor physics was perceived as easy by most of the Physics students, although more thought that biology might be easy (26%, 16%, $p<0.01$). Physics students also tended to think that biology, more than physics, required factual recall rather than conceptual understanding (49%, 17%, $p<0.001$), perhaps because they viewed it as mathematically-based (4%, 89%, $p<0.001$). Physics students also saw there own science as requiring more work than biology (57%, 77%, $p<0.001$).

Relevance and benefits of the subjects

Physics students, unlike their biology counterparts, saw biology as less relevant to everyday life in general terms (21%, 14%, $p<0.05$). However, the situation was reversed in the context of more specific problems such as environmental (67%, 32%, $p<0.001$) or medical (97%, 53%, $p<0.001$) problems, when biology was seen as more applicable. When it came to personal benefits in the form of employment, however, Physics students saw their own subject as advantageous both in terms of variety of employment opportunities (61%, 92%, $p<0.001$) and remuneration (32%, 68%, $p<0.001$).

Types of people

Like the Biology students, about a quarter of the AS-level Physics students thought that physics, but not biology, was more appropriate to males (1%, 26%, $p<0.001$), and that biology was more suited to girls (14%, 2%, $p<0.001$). Perhaps surprisingly, a proportion of the Physics students thought that those who were attracted to physics (but less so for those attracted to biology) lacked social skills (8%, 13%).

Communication of the subjects

AS-level Physics students did not distinguish between their own subject and biology when asked if the sciences used difficult vocabulary (50%, 43%), although they did think that their own subject made use of 'everyday' words with special meanings (9%, 23%, $p<0.005$).

7.3.5 Views of students taking AS-level English

Nature of the subjects

The third cohort of students consisted of those who were taking no science subjects but were taking AS-level English. Over a third of these students liked biology compared to just over a tenth of the students liking physics (39%, 12%, $p<0.001$). Over two thirds of the English students thought that biology was interesting compared to only a quarter finding physics interesting. In a similar way more found physics boring rather than biology (23%, 64%, $p<0.001$).

Academic demands of the subjects

In terms of some of the academic demands of the subjects, English students appeared to distinguish between biology and physics. Few of the English students thought that both biology and physics were easy, but there were significantly more thinking biology was easy in comparison to physics (12%, 4%, $p<0.001$). About a third thought that both biology and physics were more concerned with remembering facts than with understanding (34%, 28%). About two thirds of the English students thought that biology and physics involved a lot of work (60%, 73%, $p<0.05$). The students doing English saw biology and physics as very different in their requirement for mathematics, with few of the English students thinking that biology required mathematics and about three quarters of them thinking that physics required mathematics (8%, 77%, $p<0.001$).

Relevance and benefits of the subjects

AS-level English students, like the biology students, thought that biology was less irrelevant to everyday life than physics (14%, 34%, $p<0.001$). This was further supported with more of these students feeling that biology could help solve environmental problems than physics (52%, 24%, $p<0.001$) and substantially more thinking that biology can help solve medial problems than physics (90%, 27%, $p<0.001$). In terms of personal benefit, more AS-level English students saw qualifications in biology than physics offering a variety of employment opportunities (66%, 53%, $p<0.05$), whilst similar proportions of students saw qualifications in biology and physics as leading to higher-paid jobs (34%, 38%).

Types of people

More of the AS-level English students thought that physics was more suited to boys than girls (2%, 14% $p>0.001$). A few students thought that biology was more a girls subject than physics (5%, 1%, $p<0.01$). The situation was reversed when asked about the lack of social skills. More English students felt that physicists lacked social skills than biologists (1%, 5%, $p<0.01$).

Communication of the subjects

Two of the questionnaire items sought students' opinions the language used to teach biology and physics. The perception of many of the English students was that both biology and physics use difficult words (43%, 51%). A similar proportion of students thought that both biology and physics use a non-specialist language (20%, 14%).

7.3.6 Comparison of ideas of male and female students

The responses of the males and females students, following either biology, physics or English AS-level, where examined to identify any differences in responses to the questionnaires Figure 7.5-7.7. In the descriptions below, the percentages given first are for the males, followed by those for the females. Only those cases in which a statistically significant difference ($p<0.05$) occurred between the responses of the males and females are given below.

Male and Female AS-level biology students' responses

Rather few differences between the male and female responses were found among the AS-level Biology students. However, significantly more of the males expressed an overall liking for physics (29%, 11%, $p<0.05$) (Figure 7.5). Gender differences were also found among student's views about biology, with more males than females thinking that physics was interesting

(51%, 16%, p<0.000) and more females believing that physics is boring (41%, 59%, p<0.05).

Figure 7.5 Distribution of responses of male and female biology students to questionnaire items about biology and physics

	Views about ***Biology***			Views about ***Physics***		
	Males (% affirm)	p	Females (% affirm)	Males (% affirm)	p	Females (% affirm)
Nature of the subject						
Like the subject	76	ns	87	29	.05	11
Interesting	83	ns	88	51	.000	16
Boring	8	ns	1	41	.05	59
Academic demands of subject						
Easy	17	ns	20	4	ns	4
Remembering facts rather than understanding	32	ns	24	12	ns	25
Lots of work	85	ns	85	71	ns	72
Good at maths	11	ns	6	84	ns	89
Relevance and benefits of subject						
Irrelevant to everyday life	11	ns	12	29	ns	26
Help solve environmental problems	62	ns	47	14	ns	22
Help solve medical problems	94	ns	89	35	ns	37
Lots of different jobs	87	ns	86	71	ns	62
Well-paid jobs	35	ns	35	51	ns	43
Types of student						
More a boys subject	6	ns	1	29	ns	26
More a girls subject	8	ns	6	0	ns	0
People who don't mix well	2	ns	0	18	ns	7
Communication of subject						
Uses lots of difficult words	53	ns	45	51	ns	47
Uses everyday words with different meanings	9	ns	16	16	ns	23

The percentages show the proportion of AS-level biology students in each cohort who affirmed the idea, giving either 'I strongly agree' or 'I agree' responses. P Calculated from the Chi Squared test.

Male and Female AS-level physics students' responses

The only apparent difference between the male and female AS-level Physics students' responses to questionnaire items about biology and physics was in the liking of biology. It was observed that significantly more females who studied physics liked biology than males (19%, 42%, $p<0.05$)

Figure 7.6 Distribution of responses of male and female physics students to questionnaire items about biology and physics

	Views about *Biology*			Views about *Physics*		
	Males (% affirm)	p	Females (% affirm)	Males (% affirm)	p	Females (% affirm)
Nature of the subject						
Like the subject	19	0.05	42	80	ns	100
Interesting	39	ns	50	84	ns	92
Boring	39	ns	50	17	ns	0
Academic demands of subject						
Easy	24	ns	33	15	ns	17
Remembering facts rather than understanding	50	ns	42	18	ns	0
Lots of work	59	ns	50	77	ns	83
Good at maths	5	ns	8	88	ns	92
Relevance and benefits of subject						
Irrelevant to everyday life	21	ns	17	16	ns	8
Help solve environmental problems	66	ns	67	35	ns	17
Help solve medical problems	96	ns	100	51	ns	68
Lots of different jobs	62	ns	50	94	ns	83
Well-paid jobs	34	ns	17	68	ns	50
Types of student						
More a boys subject	1	ns	0	27	ns	8
More a girls subject	14	ns	17	2	ns	0
People who don't mix well	9	ns	0	15	ns	8
Communication of subject						
Uses lots of difficult words	54	ns	25	39	ns	58
Uses everyday words with different meanings	6	ns	25	27	ns	17

The percentages show the proportion of AS-level physics students in each cohort who affirmed the idea, giving either 'I strongly agree' or 'I agree' responses. P calculated by Chi Squared test.

Male and Female AS-level English students' responses

As with the other sub-sets of students, rather few differences between the male and female AS-level English students were found. More of the females expressed an interest in biology (49%, 64%$p<0.05$) (Figure 7.7).

Differences were also found among student's views about physics with more males than females thinking that people who study physics (13%, 2%, p<0.05) do not mix well with others. More males thought of physics as providing well paid jobs (37%, 25%, p<0.01).

Figure 7.7 Distribution of responses of male and female English students' to questionnaire items about biology and physics

	Views about *Biology*			Views about *Physics*		
	Males % affirm	p	Females % affirm	Males % affirm	p	Females % affirm
Nature of the subject						
Like the subject	35	ns	42	18	ns	10
Interesting	49	.05	64	28	ns	20
Boring	25	ns	21	53	ns	67
Academic demands of subject						
Easy	11	ns	14	7	ns	2
Remembering facts rather than understanding	39	ns	32	21	ns	30
Lots of work	56	ns	62	67	ns	74
Good at maths	11	ns	16	83	ns	75
Relevance and benefits of subject						
Irrelevant to everyday life	14	ns	14	16	.001	41
Help solve environmental problems	51	ns	53	26	ns	23
Help solve medical problems	87	ns	92	33	ns	26
Lots of different jobs	58	ns	69	54	ns	51
Well-paid jobs	40	ns	29	53	.004	30
Types of student						
More a boys subject	2	ns	2	11	ns	15
More a girls subject	5	ns	5	0	ns	1
People who don't mix well	2	ns	1	13	.05	2
Communication of subject						
Uses lots of difficult words	47	ns	42	46	ns	53
Uses everyday words with different meanings	18	ns	21	12	ns	14

The percentages show the proportion of AS-level English students who affirmed the idea, giving either 'I strongly agree' or 'I agree' responses. Chi Squared test.

7.3.7 Themes in AS-level students' thinking

Rotated Varimax Factor Analysis of the AS-level students' responses produced 12 factors and extracted 62% of the total variance (Figure 7.8). The items placed by factor analysis in each factor were examined for a common theme and then, if possible, the factor was 'named' to encapsulate the theme.

Factor 1 included questionnaire items that embraced ideas about only physics; whether or not it was generally likeable, interesting, and easy. In addition, the questionnaire items about physics being boring and irrelevant to everyday were included, but with a negative value suggesting an opposite polarity. The link between these items appears to be that of a general view of physics, so this factor was named '*Perceived characteristics of physics*'.

Factor 2 included items that embraced ideas about only biology; whether the subject was liked or was interesting. As with the first factor, the questionnaire item about the subject being boring and irrelevant to everyday life was included but with negative values suggesting an opposite polarity. The link between these items appears to be that of a general view about biology, so this factor was named '*Perceived characteristics of biology*'. The fact that such properties were distributed in different factors might indicate that AS-level students distinguish between physics and biology in terms of these general characteristics.

Figure 7.8 Rotated Varimax Factor Analysis of responses of AS-level students responses to items about biology and physics

	Factor Number									
Questionnaire item	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
P-How feel about?	.867									
P-Interesting subject	.859									
P-Boring subject	-.852									
P-Irrelevant to everyday life	-.586									
P-Easy subject	.566									
B-Boring subject		-.882								
B-Interesting subject		.869								
B-How feel about?		.869								
B-Irrelevant to everyday life		-.434								
B-Girls subject			.841							
B-Boys subject			.781							
P-Boys subject			.750							
P-Girls subject			.742							
P-Solve medical problems				.690						
P-Solve environmental problems				.592						
B-Lots of different jobs		.451		.509						
B-Solve medical problems				.476						
B-Solve environmental problems				.421						
P-Lots of different jobs				.390				-.363		
B-Needs lots of work					.726					
B-Uses difficult words					.690					
B-Easy Subject					-.470					
P-Need mathematics						.732				
P-Needs lots of work						.524				
P-Uses difficult words	-.352					.414				
B-Well paid jobs							.688			
P-Well paid jobs						.392	.655			
B-More remembering facts							.401			
P-People don't mix well								.650		
B-People don't mix well		-.375						.499		
B-Uses everyday words									.722	
P-Uses everyday words									.721	
B- Need mathematics										.828
P- More remembering facts										.456

Factors
1 Perceived characteristics of physics
2 Perceived characteristics of biology
3 Personal suitability for science
4 Social benefits of physics
5 The academic demands of biology
6 The academic demands of physics
7 Not named
8 Not named
9 Not named
10 Not named

Factor 4 encompassed the responses to do with questions about the *'Social benefits of physics'* such as about the environmental and medical benefits of the subject as well as the employment prospects of the subjects.

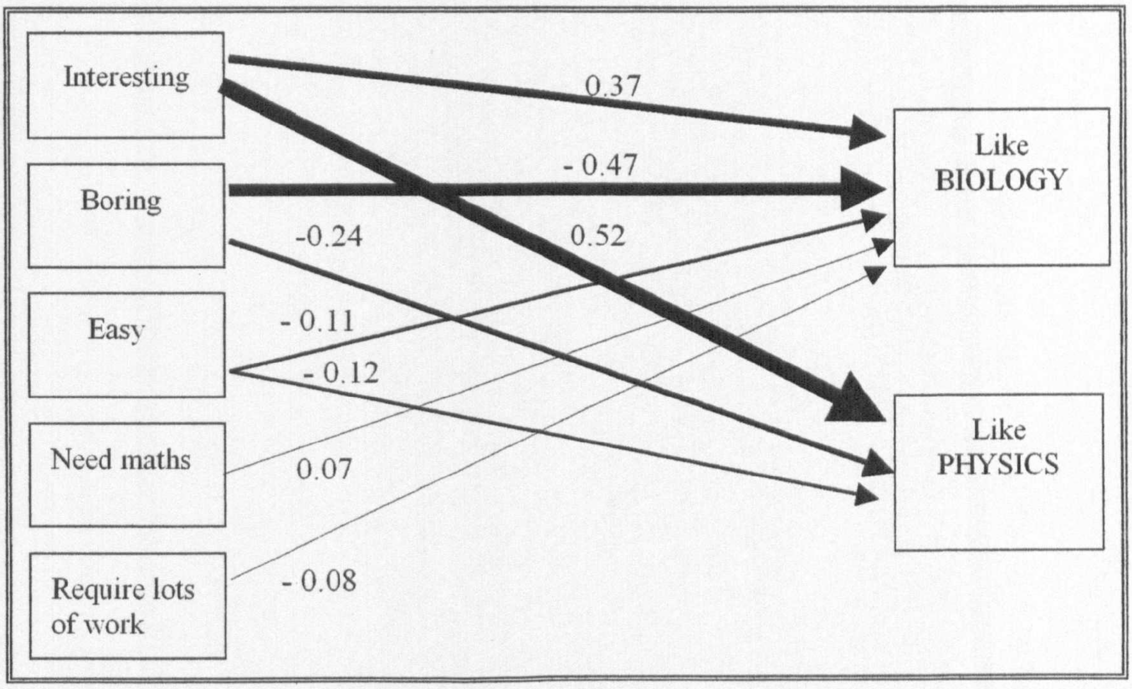
The fifth and six factors both embraced factors to do with *'the academic demands'* of the subjects. Factor 5 dealt with the academic demands of biology linking the need to do lots of work and the use of difficult words to, with an opposite polarity, the ease of biology. Factor 6 dealt with the academic demands of physics; it grouped the need to be good at mathematics, the need for lots of work and the use of difficult words in physics.

The third factor embraced items about both physics and biology. Factor 3 related to the sorts of people who might or might not be suited to biology and physics; in terms of whether the subject was a girls or boys subject for both biology and physics. This factor was therefore called *'Personal suitability for science'*. None of the remaining factors had clear themes, so they were left unnamed.

7.3.8 Reasons underpinning differential views of AS-level students

Following the results of factor analysis, regression analysis was used to explore reasons that might underpin AS-level students' general feelings about biology and physics. Regression Analysis was performed using responses to the general item ('How do you feel about…') as the dependent variable (Figure 7.9).

Figure 7.9 Reasons that might underpin Year 11 students' differential views about biology and physics



In the case of biology, five of the variables showed significant associations. The students who like biology find it interesting ($p<0.001$) and not boring ($p<0.001$). There were weaker (but still statistically significant) associations between a liking for biology and the ideas that a knowledge of mathematics is needed ($p<0.05$), if they found biology easy ($p<0.001$) and, to a lesser extent, if they thought the subject required lots of hard work ($p<0.005$). For physics, the responses to four specific questionnaire items showed significant associations with those from the general item about liking physics. Thus, those who like physics in this age group are more likely to be those who find the subject interesting ($p<0.001$) and reject the notion that it is boring ($p<0.05$) and find physics easy ($p<0.001$).

7.4 DISCUSSION

The results of this section of the present study reveal the attitudes of AS-level students to physics compared with their attitudes to biology. They support the work of (Harvard, 1996) that showed that AS-level students hold different views about biology and physics, implying that they do not regard science as a homogenous subject. The present results show that other than among students who had elected to study physics at AS-level, physics was less popular than biology and was viewed as less interesting, as more of a boys subject, as requiring ability in mathematics. Physics was also seen as less likely to contribute to the solutions to medical and environmental problems. These findings highlight the need to distinguish between the sciences when exploring students' attitudes.

The results of this section of the present study also suggest possible reasons why students elect to embark on different AS-level courses, in English, biology or physics and why students may feel positive or negative about biology or physics. The responses of the students who have elected to follow AS-level English might be taken to represent the perceptions of a group of young adults who are academically able but whose formal contact with science ceased at GCSE level. Such students tended to like biology more than physics. This distinction appeared to be based on a view that physics was academically more difficult than biology and that it required more work and, as mentioned previously, that it required more mathematical ability. More of the AS-level English students thought that physics was less likely to contribute to solving medical and environmental problems. Also, more of this group of students regarded biology as interesting, and more rejected the idea that it is boring.

7.4.1 Views of AS-level English Students

One possible reason for the differences in English students' perceptions of biology and physics could be that biology is seen as more readily accessible than physics. It may be that biology is perceived, by non-scientists, as dealing with things that can be related to everyday life, such as human physiology, and behaviour. Furthermore, and perhaps related to its accessibility, biology may be the subject of popular science programmes in the popular media to a greater extent than physics. Such areas have been identified as factors that make science interesting to students (Student Review of the Science Curriculum, 2003).

It is, however, worth noting that although the English students in this study thought of biology as the more popular of the two sciences, they have chosen not to follow a pathway into the science field, but instead have chosen to follow a subject which is thought to offer more academic freedom (Watson *et al*, 1994). Further research is therefore necessary to identify whether the perceived academic freedom offered by the different sciences influences the decision to study the subjects past GCSE level.

7.4.2 Views of AS-level physics students

Not surprisingly, students who had chosen to go against the trend and study AS-level Physics liked their subject. This was despite the fact that few of them found physics easy and many considered that their subject carries a high workload and required mathematical skills. The importance of career choice to students making their subject decisions after GCSEs is still debated. However, it has been suggested that the perceived value of physics in terms of potential employability influences the decision to continue the subject beyond GCSE level (Reid and Skryabina, 2002; Woolnough, 1994). This is supported by the results of the present research in which there were signs that physics students believed that a qualification in physics rather than biology offers a greater variety of employment opportunities. Interestingly, physics students did not perceive their subject as one that offers solutions to environmental and medical problems in comparison to biology.

7.4.3 Views of AS-level Biology students

Not surprisingly, nearly all of the biology students liked their subject. This was reflected in their feeling that biology was interesting, although not necessarily easy. The AS-level biology students also tended to think that biology, as opposed to physics, had more potential to solve environmental and medical problems. Perhaps linked to this, they thought that biology was generally more 'relevant' to everyday life. Biology students have stated that they *"like biology because this is to do with everyday life and your body, and the things that happen around you"* (Student Review of the Science Curriculum, 2003). There was a big difference in the biologists' view of the requirement for mathematical ability for the two subjects; only a tenth thought this was needed for biology but almost all thought that it was needed for physics.

7.4.4 Students choice of AS/A-level subjects

There are many factors that may influence students' A-level decisions (Woolnough 1994a, 1994b; de Almeida, Leite and Woolnough, 1998; Harvard, 1994). Some of these factors are dependent on individual students themselves, such as their abilities and intrinsic preferences. However, some students do not choose to follow a field into science because, even though they are academically capable of studying science at AS-level, their strengths and or preferences do not lie in the scientific field. Other factors such as the career prospects and social status are less dependent on the individual but have been shown, in this study and in previous studies, to play a role in influencing student choices (Reid and Skryabina, 2002; Woolnough 1994a).

However, there are factors that are under the influence of the learning environment – such as the teaching; the teaching methods used, the quality of teaching and the degree of encouragement received by students may all influence students choice. One area, the curriculum, is to some extent out of the control of teachers but has been identified as factor that can influence subject choice. One student stated that

> *"I have never, nor will I ever, either see the point in or understand physics. It always seemed pointless spending hours of experimental time proving what was already proven, or that black wasn't a colour, or whatever."*
>
> (School Science Curriculum Review, 2003).

It was shown in Chapter 4 of this present study that there is an association, amongst Year 11 secondary school students, between a liking for physics and the view that it is interesting, easy and relevant to everyday life. This association appears to persist in AS-level students. This is significant because there is evidence that students who perceive a subject as interesting do actually elect to pursue it (Watson, McEwen and Dawson, 1994) in the present case from AS-level to A-level, and perhaps onward into tertiary education. For this reason, the aim of the next chapter is to explore the attitudes of undergraduate students to physics, to attempt to identify what underpins students' choices to follow particular subjects at tertiary level.

Appendix 7.1

Letter to schools requesting participation

Dear

I am a student at the University of Liverpool and I am undertaking a dissertation into young people's perceptions of physics and biology. In particular, I am interested in the views of 'A' level students. This is part of a research programme being run by the Science Communication Unit at the University of Liverpool. We are interested in young people's views because decreasing numbers of students are taking physics at 'A' level. The aim of my dissertation is to discover what makes biology more appealing to students than physics.

A questionnaire will be used to compare students' views about biology and physics. Your college is one of eight Community Colleges in Liverpool and the surrounding areas that I am approaching to help me carry out this research.

I do realise that lecturers have very busy schedules and so I would be extremely grateful if you would allow me to conduct questionnaires with some of your students. The questionnaires are confidential and are in no way intended to judge lecturers or institutions.

I shall telephone in a few days to ask whether you are able to help me with this project. Naturally, I will be pleased to answer any enquiries.

Yours Sincerely

Katie Spall (Ms)

Appendix 7.2

Guidance notes for teachers administering the questionnaires

NOTES FOR GUIDANCE.

- Please ensure that the questionnaires are completed fully (all three pages).
- Please carry the questionnaires out under 'examination conditions' to ensure that students do not compare answers, but with no time limit.
- Please do not allow students to take the questionnaires away with them – the questionnaires should be filled in 'then and there'.
- Please do not influence students' responses, as this would invalidate the data collected.
- Please make sure students only fill in one copy of the questionnaire as it will be given to other subject classes i.e. check no one has done it before.
- Please collect all completed questionnaires and spare copies and return them to the file for collection.

Thank you for your time and help in this project,

Katie Spall and Gemma Holcroft,
Science Communication Unit,
University Of Liverpool

UNDERGRADUATES' CONSTRUCTIONS OF BIOLOGY AND PHYSICS

Chapter Eight

8.1 INTRODUCTION

In the previous chapter AS-level students' attitudes towards physics and biology were explored. In this chapter the views of students in the final level of the education system, university undergraduates, are explored. The aim is to determine the extent to which views about physics that develop during secondary schooling, and appear to persist into AS-level students, extend to university undergraduates. In addition, the aim is to reveal what underpins students' choice to follow a science in particular programme of study, physics or biology.

8.1.1 Background

In this present chapter, we compare the views of three cohorts of Year 1 undergraduate students at the University of Liverpool, those on English, Physics and Biology Programmes of Study. Students on an English Programme of Study represent those educated to tertiary level, but with no particular interest in, or advanced experience of, science. Students on a Physics Programme of Study are those who have chosen, despite the general trend, to study physics at university level. Undergraduates on a Biology Programme of Study represent those who have an interest in science but who have elected at some stage to study biology rather than another science, such as physics.

This section of the study is designed to try to clarify the role of a variety of factors that might have been influential in undergraduate students' choices. This may be useful in providing information that is of potential interest to both school and university educators. For example, Russell (1992) has argued that the views of those who had, in fact taken up technological career paths could be informative, if it was considered important to increase the number of pupils taking science with a view to working in such careers. In the same sense, the views of those who have chosen not to follow such career paths are of importance to decipher which factors may be acting as a deterrent to some students pursuing higher education and, subsequently, a career in science.

8.2 METHODS

8.2.1 Questionnaire design and administration

In this study, Year 1 undergraduates' views about biology and physics were explored using a closed-form questionnaire. This questionnaire was similar to the questionnaire used to explore the ideas of secondary school students as described in Chapter 4. It used the same 16 closed-form items for physics and biology (see Figure 4.4). In addition to this the coversheet was a modified to make it suitable for undergraduate students (Appendix 8.1). This questionnaire was piloted with 40 undergraduate students (50% male, 50% female; 50% studying arts subjects, 50% studying science subjects). Year 2 students were chosen, to avoid any student from the main study, which was to be conducted with Year 1 students, being exposed to the questionnaire in advance. Examination of the responses and informal conversations with the respondents suggested that the wording of the questionnaire items was satisfactory other than one minor issue concerning wording. The coversheet of the questionnaire had originally asked students which Programme of Study they were following. Year 1 students tended to be unfamiliar with the relatively new official terminology ('Programme of Study') and think in terms of 'potential Honours school' or 'main subject'; the wording of the item was changed to accommodate this.

The final questionnaire was arranged in three sections. The coversheet asked students to confirm their year group, and to record their age, gender and Programme of Study. In addition, the coversheet contained two items asking students about their general feelings about biology and physics. The rest of the questionnaire layout was the same as described in section 4.4. The final questionnaire was administered in regular lectures or, in the case of the biologists, regular practical classes. Examination conditions prevailed, although no time limit was imposed.

8.2.2 Data analyses

Students' responses were encoded onto an SPSS database. The original database contained responses from 463 Year 1 undergraduate students. The responses of students aged 24 years and over were removed from the data set, to introduce some homogeneity into the sample. In order to gain insight into questionnaire reliability, the distribution of responses to each item were compared between randomly split halves of the respondent sample. The correlation coefficients between these two sub-samples were calculated for each item. The mean correlation coefficient for all items was 0.977, with a maximum of 1.000 and a minimum of 0.804, indicating a high consistency of response.

For the presentation of the data, the 'strongly agree' and 'agree' responses were combined to give the proportions of students who affirmed the idea (Figures 8.1 and 8.2, and descriptions below). The differences between the responses of the students on the three programmes of study, and between male and female students were explored using analysis of variance (ANOVA) because the proportions of male and females students on the three programmes were different. Cluster analysis was used to determine whether students could be grouped according to their responses. Regression analysis was employed to determine whether there were statistically significant associations between the responses to questionnaire items about the individual characteristics of the subjects and those to the items concerning the level of general 'liking' of the subjects. ANOVA, cluster analysis and regression were undertaken using the original, five-response-category data. For some analyses the 'strongly agree' and 'agree' responses were combined (to reflect the data in the tables), as were the 'neither agree nor disagree', 'disagree' and 'strongly disagree' responses. Using these combined data, students' responses to parallel questionnaire items about physics and biology were compared using the McNemar test, and the responses of students in the two groups produced by cluster analysis were compared using the chi-square test.

8.3 RESULTS

8.3.1 Description of the respondent group

Following removal of the responses from students aged 24 years and over, there were responses from 439 students, 78 on an English Programme of Study, 60 on a Physics Programme of Study and 301 on a Biology Programme of Study. Amongst these, there were 178 males and 259 females (with 2 students failing to record their gender). The responses of students on different undergraduate degree programmes to the questionnaire items are shown in Appendix 8.2.

8.3.2 Overall layout

In the descriptions below, unless otherwise stated, the percentages given first are for the responses to the questionnaire items about biology; those that follow are for the responses to the equivalent questionnaire item about physics. Where the results were statistically significantly different, the p value is given. Although the questions were in random order on the actual questionnaire, here they are considered under a number of themes covered by the questionnaire.

8.3.3 Views of undergraduates on the English Programme of Study

The responses of the English undergraduate students could be considered to represent the views of educated, but non-scientific young adults (figure8.2).

Nature of the subjects

More of the English undergraduates expressed a general liking for biology than for physics (41%, 15%, $p<0.001$). More of this group of students also thought that biology, as opposed to physics, was interesting (76%, 32%, $p<0.001$) and, in a complementary manner, fewer thought that biology was boring (17%, 55%, $p<0.001$).

Academic demands of the subjects

In terms of some of the academic demands of the subjects, English undergraduate students appeared not to distinguish between biology and physics. Very few of the English students thought that both biology and physics were easy (4%, 3%), and only about a fifth thought that both biology and physics were more concerned with remembering facts than with understanding (19%, 17%).

About two thirds of the undergraduates thought that biology and physics involved a lot of work (60%, 69%). Thus, the undergraduates on the English Programme of Study envisaged both biology and physics as difficult subjects which demanded conceptual understanding and a high workload. In contrast, biology and physics were seen as very different in their requirement for mathematics, with few of the English students thinking that biology required mathematics and almost all of them thinking that physics required mathematics (12%, 90%, $p<0.001$).

Figure 8.2 Views of undergraduates on the English Programme of Study

	Views of students on English programme		
	Views about **biology** (% affirm)	p	Views about **physics** (% affirm)
Nature of the subject			
Like the subject	41	0.001	15
Interesting	76	0.001	32
Boring	17	0.001	55
Academic demands of subject			
Easy	4		3
Remembering facts rather than understanding	19		17
Lots of work	60		69
Good at maths	12	0.001	90
Relevance and benefits of subject			
Irrelevant to everyday life	14		21
Help solve environmental problems	59	0.001	36
Help solve medical problems	92	0.001	49
Lots of different jobs	68		60
Well-paid jobs	23		35
Types of student			
More a boys subject	1	0.001	23
More a girls subject	4		0
People who don't mix well	5		10
Communication of subject			
Uses lots of difficult words	40		46
Uses everyday words with different meanings	8		15

The percentages show the proportion of undergraduate students in each cohort who affirmed the idea, giving either 'I strongly agree' or 'I agree' responses. In the case of the first item ('like the subject') the combined responses were 'I really like Biology (*or* Physics)' and 'I quite like Biology (*or* Physics)'

Relevance and benefits of the subjects

Fewer of the English undergraduates thought that biology, compared to physics, was irrelevant to everyday life (14%, 21%). In terms of solutions to problems, more of these students thought that biology, as opposed to physics, could contribute to the solution of environmental problems (59%, 36%, $p<0.001$) and medical problems (92%, 49%, $p<0.001$). In terms of personal benefit, similar proportions of students saw qualifications in biology and physics as offering a variety of employment opportunities (68%, 60%), and as leading to higher-paid jobs (23%, 35%).

Types of people

Some of the questionnaire items probed undergraduate students' views about the types of people who might be suited to biology or physics. Rather few of the English students thought that biology or physics were more suitable for females (4%, 0%). In contrast, nearly a quarter of the undergraduates thought that males were more suited to physics (1%, 23%, $p<0.001$). Low proportions of students felt that people who studied the subjects did not mix well (5%, 10%).

Communication of the subjects

Two of the questionnaire items sought students' opinions on the language used to teach biology and physics. The perception of many of the English students was that both biology and physics use difficult words (40%, 46%) rather than non-specialist language (8%, 15%).

8.3.4 Views of undergraduates on the Physics Programme of Study

The responses of the students on the physics programme of study are described as above, for consistency (Figure 8.3). Hence, the first figure in parentheses shows the percentages of students affirming a view about biology, the second, those affirming the same view about physics.

Nature of the subjects

As might be expected, almost all of the physics students expressed a liking for physics, although more than a third expressed a liking for biology (40%, 95%, $p<0.001$). Similarly, almost all of the physics cohort found physics interesting (65%, 97%, $p<0.001$) and relatively few found it boring (27%, 13%).

Academic demands of the subjects

Few of the physics undergraduate students thought that physics was easy, whereas about a quarter of them thought that biology was (23%, 8%, $p<0.05$). Although two thirds of this group of students thought that studying biology involved a high workload, even more thought this true of physics (68%, 83%). Whereas biology was seen by about half of the physics undergraduate as being more to do with factual recall than comprehension, very few of them thought this true for physics (52%, 3%, $p<0.001$). Almost all of the physics students affirmed that physics required mathematical ability, but biology was seen as a non-mathematical subject (5%, 93%, $p<0.001$). Thus, physics undergraduates tended to view their own subject as rather different from biology, with physics being more conceptual and mathematically based.

Relevance and benefits of the subjects

About a fifth of the physics undergraduate students supported the idea that biology and physics were irrelevant to everyday life (23%, 17%). Perhaps more revealingly, many more of the students rejected this idea ('disagree' plus 'strongly disagree' responses) about physics (72%) than biology (48%). Most of the undergraduates envisaged physics and biology as having a role in the solution of environmental problems (67%, 75%), but in the case of medical problems, more saw biology as the potential benefactor (95%, 85%, $p<0.05$). Physics undergraduates tended to see physics more than biology as leading to a variety of job opportunities (88%, 62%, $p<0.001$), although this difference did not apply to the perceived level of remuneration (37%, 47%).

Figure 8.3 The views of physics students about biology and physics

	Views of students on Physics programme		
	Views about **biology** (% affirm)	p	Views about **physics** (% affirm)
Nature of the subject			
Like the subject	40	0.001	95
Interesting	65	0.001	97
Boring	27		13
Academic demands of subject			
Easy	23	0.05	8
Remembering facts rather than understanding	52	0.001	3
Lots of work	68		83
Good at maths	5	0.001	93
Relevance and benefits of subject			
Irrelevant to everyday life	23		17
Help solve environmental problems	67		75
Help solve medical problems	95	0.05	85
Lots of different jobs	62	0.001	88
Well-paid jobs	37		47
Types of student			
More a boys subject	2	0.001	48
More a girls subject	23		0
People who don't mix well	5		17
Communication of subject			
Uses lots of difficult words	47	0.05	27
Uses everyday words with different meanings	10	0.001	33

Types of student

Some of the physics undergraduates appeared to think that biology and physics were suited to different genders. Thus, whereas very few physics students thought that males were better suited to biology, nearly a half thought that males were better suited to physics (2%, 48%, $p<0.001$). In a complementary manner, whereas about a quarter of the undergraduate physicists thought that females were better suited to biology, none thought that females were better suited to physics (23%, 0%). Perhaps surprisingly, whereas few of the physics students thought that people who took biology did not socialise easily, more thought that people who took physics did not mix well (5%, 17%).

Communication of the subjects

About half of the physics students affirmed that the study of biology required difficult words, whereas fewer thought this true of physics (47%, 27%, $p<0.05$). In a complementary manner, fewer of the physics undergraduates affirmed that biology, as opposed to physics, employed everyday words with particular meanings than thought this so of physics (10%, 33%, $p<0.001$).

8.3.5 Views of undergraduates on the Biology Programme of Study

The views of the biology undergraduate students may be considered to represent the views of students who are interested in science, but who elected to take biology rather than another science, such as physics, at degree level.

Nature of the subjects

As might be expected, almost all of the biology undergraduate students liked biology, whereas only a quarter liked physics (96%, 22%, $p<0.001$). This was reflected in their views about whether they found the subjects interesting (97%, 39%, p<0.001) or boring (1%, 44%, p<0.001).

Figure 8.4 The views of biology undergraduate students about biology and physics

	Views of students on Biology programme		
	Views about **biology** (% affirm)	p	Views about **physics** (% affirm)
Nature of the subject			
Like the subject	96	0.001	22
Interesting	97	0.001	39
Boring	1	0.001	44
Academic demands of subject			
Easy	15	0.001	1
Remembering facts rather than understanding	15		12
Lots of work	71	0.05	64
Good at maths	23	0.001	91
Relevance and benefits of subject			
Irrelevant to everyday life	7	0.001	17
Help solve environmental problems	84	0.001	28
Help solve medical problems	98	0.001	62
Lots of different jobs	88	0.001	65
Well-paid jobs	18	0.001	39
Types of student			
More a boys subject	1	0.001	27
More a girls subject	6		0
People who don't mix well	2	0.001	15
Communication of subject			
Uses lots of difficult words	39		32
Uses everyday words with different meanings	8	0.05	13

Academic demands of the subjects

Only a relatively small proportion of the biology undergraduate students thought that biology was an easy subject, but almost none of these students thought this true of physics (15%, 1%, p<0.001). Nearly three quarters thought that the study of biology involved a high workload, with somewhat fewer thinking this true of physics (71%, 64%, p<0.05). Rather few of the students believed that either biology or physics was based on factual recall rather than conceptual understanding (15%, 12%). About a quarter of the students affirmed that mathematical ability is a component of biology, but nearly all students thought this true of physics (23%, 91%, $p<0.001$). Thus, although biologists see both subjects as conceptual, they draw a distinction between the two disciplines in terms of their mathematical basis.

Relevance and benefits of the subjects

Few of the biology undergraduate students supported the notion that biology was irrelevant to everyday life, but more thought this true about physics (7%, 17%, $p<0.001$). In fact, more than three quarters of the biologists (79%) rejected the idea that biology was irrelevant, and half rejected the idea that physics is irrelevant (49%). More of the biology students considered that biology, rather than physics, could make a contribution to solving environmental problems (84%, 28%, $p<0.001$) and medical problems (98%, 62%, $p<0.001$). In terms of personal benefit, more biologists believed that biology as opposed to physics would lead to a variety of employment opportunities (88%, 65%, $p<0.001$). However, in contrast, more biologists thought physics would lead to better paid jobs (18%, 39%, $p<0.001$).

Types of student

A few of the biology undergraduate students felt that biology is more suited to females, although none thought this true of physics (6%, 0%). However, although very few of the biologists thought that biology is better suited to males, more than a quarter thought that physics is more suited to males (1%, 27%, $p<0.001$). Rather few of the biology undergraduates thought that people who study biology mix less well than others, but more thought this true of people who study physics (2%, 15%, $p<0.001$).

Communication of the subjects

About a third of the biology students envisaged that the study of both biology and physics requires the use of difficult words (39%, 32%). Fewer students thought that the subjects, especially biology, were taught using everyday words with specialist meanings (8%, 13%, $p<0.05$).

8.3.6 Comparison of ideas of male and female students

As in previous chapters, the responses of the male and female undergraduate students were compared. The distribution of male and female students was dissimilar amongst the different subject cohorts (those studying English, physics and biology), so the responses of male and female students were compared using analysis of variance; in this way that the confounding effect of the different proportions of males and females on the different Programmes of Study could be excluded (figure 8.5). In the descriptions below, the percentages given first are for the males, followed by those for the females. Only those cases in which a statistically significant difference ($p<0.05$) occurred between the responses of the males and females are given below. More of the males expressed an overall liking for physics (48%, 19%), although more males also thought that physics is not relevant to everyday life (20%, 16%). Gender differences were also found among student's views about biology, with more females than males thinking that biology required mathematical skills (12%, 23%) and more females believing that biology could contribute to the amelioration of environmental problems (73%, 80%). More of the males thought that people who study biology (5%, 2%) or physics (20%, 10%) do not mix well with others. More males than females thought of biology as a girls subject (11%, 6%) and more males thought of physics as a boys subject (37%, 25%), perhaps suggesting that males tend to show more gender bias than females.

Figure 8.5 Distribution of responses of male and female undergraduate students to questionnaire items about biology and physics

	Views about *Biology*			Views about *Physics*		
	Males (% affirm)	p	Females (% affirm)	Males (% affirm)	p	Females (% affirm)
Nature of the subject						
Like the subject	71		84	48	0.05	19
Interesting	83		93	57		37
Boring	8		7	39		43
Academic demands of subject						
Easy	16		12	4		1
Remembering facts rather than understanding	30		14	10		13
Lots of work	70		68	69		66
Good at maths	12	0.05	23	92		91
Relevance and benefits of subject						
Irrelevant to everyday life	13		9	20	0.05	16
Help solve environmental problems	73	0.05	80	41		32
Help solve medical problems	96		98	63		62
Lots of different jobs	73	0.05	86	66		68
Well-paid jobs	24		20	36		41
Types of student						
More a boys subject	2		0	37	0.001	25
More a girls subject	11	0.001	6	0		0
People who don't mix well	5	0.001	2	20	0.001	10
Communication of subject						
Uses lots of difficult words	48		35	33		35
Uses everyday words with different meanings	7		9	19		14

The percentages show the proportion of undergraduate biology students in each cohort who affirmed the idea, giving either 'I strongly agree' or 'I agree' responses. In the case of the first item ('like the subject') the combined responses were 'I really like Biology (*or* Physics)' and 'I quite like Biology (*or* Physics). ANOVA test.

8.3.7 Cluster analysis: subgroups of students

Biology undergraduates are students who have an interest in science, but who have elected at some stage not to study physics. As such, they might be considered as students who could, at some stage in their education, have been persuaded to study a science subject other than biology, such as physics. For this reason, the responses of the biology undergraduate students were explored further. Cluster analysis was employed to determine the extent to which the biology students represented a homogenous group.

Cluster analysis of the responses of the biology students produced two distinct groups of students. The responses of the students in the two groups were compared by Chi square analysis (Figure 8.6). In the description below, the percentages of students in Cluster Group 1 who affirmed the idea are given first, followed by those in Cluster Group 2. Generally speaking, the students in the two groups did not differ much in their views about biology. In contrast, the main distinction between the two groups appeared to be in some of their views about physics. More of the undergraduates in Cluster Group 1 liked physics (44%, 3%, $p<0.001$), thought it was interesting (73%, 9%, $p<0.001$), and fewer thought that it was boring (7%, 76%, $p<0.001$) or irrelevant to everyday life (10%, 24%, $p<0.005$).

More of the undergraduate students in Group 1 also tended to think that physics could contribute to solutions to environmental (42%, 16%, $p<0.001$) or medical (75%, 50%, $p<0.001$) problems, and very few thought that students who liked physics lacked social skills (4%, 24%, $p<0.001$).

In contrast, undergraduates in Cluster Group 2 tended to be those who did not like physics and thought it was boring rather than interesting. Fewer of these students thought that physics could contribute to environmental or medical problems. Thus, it appears that there may be a subset of students who, although having elected to join the Biology Programme of Studies, feel positive towards physics.

For comparison, a cluster analysis of the responses of physics students was undertaken. Such analysis produced two possible groups of students. As above, the responses to individual questionnaire items of the students in the two cluster groups were compared by Chi square analysis (Figure 8.7).

More of the students in Cluster Group 1 liked biology (49%, 20%, $p<0.05$) and thought it interesting (80%, 35%, $p<0.001$), despite believing that it required a lot of work (77%, 50%, $p<0.05$). Fewer of the undergraduates in Cluster Group 1 thought of biology (15%, 50%, $p<0.01$) or physics (0%, 40%, $p<0.001$) as boring. Fewer students in Group 1 thought that biology was irrelevant to everyday life (10%, 50%, $p<0.01$). Finally, fewer of the undergraduate students in Cluster Group 1 thought that physics was a boys subject (36%, 75%, $p<0.01$), or that physics was enjoyed by people who were unsociable (5%, 40%, $p<0.05$). Thus, there may be a subset of physics students who feel quite positive towards biology.

Figure 8.6 Analysis of two groups within biology students produced by cluster analysis

	Views about **biology**			Views about **physics**		
	Cluster group 1 (% affirm)	p	Cluster group 2 (% affirm)	Cluster group 1 (% affirm)	p	Cluster group 2 (% affirm)
Nature of the subject						
Like the subject	98		95	44	0.001	3
Interesting	99		96	73	0.001	9
Boring	1		1	7	0.001	76
Academic demands of subject						
Easy	14		15	2		0
Remembering facts rather than understanding	10	0.05	19	4	0.001	20
Lots of work	68		73	63		64
Good at maths	23		23	87	0.05	95
Relevance and benefits of subject						
Irrelevant to everyday life	3	0.05	11	10	0.01	24
Help solve environmental problems	85		84	42	0.001	16
Help solve medical problems	99		98	75	0.001	50
Lots of different jobs	90		85	75	0.001	55
Well-paid jobs	16		19	36		41
Types of student						
More a boys subject	1		1	24		30
More a girls subject	2	0.05	9	0		0
People who don't mix well	2		3	4	0.001	24
Communication of subject						
Uses lots of difficult words	44		35	24	0.01	39
Uses everyday words with different meanings	4	0.05	11	16		11
Independent variables						
Male (%)	40		31			
Female (%)	60		69			

The percentages show the proportion of undergraduate students in each cluster group who affirmed the idea, giving either 'I strongly agree' or 'I agree' responses. In the case of the first item ('like the subject') the combined responses were 'I really like Biology (*or* Physics)' and 'I quite like Biology' (*or* Physics). chi^2 test.

Figure 8.7 Analysis of two groups within physics students produced by cluster analysis

	Views about **biology**			Views about **Physics**		
	Cluster group 1 (% affirm)	p	Cluster group 2 (% affirm)	Cluster group 1 (% affirm)	p	Cluster group 2 (% affirm)
Nature of the subject						
Like the subject	49	0.05	20	97		90
Interesting	80	0.001	35	97		95
Boring	15	0.01	50	0	0.001	40
Academic demands of subject						
Easy	15		35	5		15
Remembering facts rather than understanding	59		40	5		0
Lots of work	77	0.05	50	90		75
Good at maths	5		5	92		95
Relevance and benefits of subject						
Irrelevant to everyday life	10	0.05	50	13		25
Help solve environmental problems	64		75	80		65
Help solve medical problems	95		95	87		80
Lots of different jobs	64		55	90		85
Well-paid jobs	28		50	41		60
Types of student						
More a boys subject	0		5	36	0.01	75
More a girls subject	15		40	0		0
People who don't mix well	3		10	5	0.05	40
Communication of subject						
Uses lots of difficult words	46		45	26		30
Uses everyday words with different meanings	10		10	33		35
Independent variables						
Male (%)	72		90			
Female (%)	28		10			

The percentages show the proportion of undergraduate students in each cluster group who affirmed the idea, giving either 'I strongly agree' or 'I agree' responses. In the case of the first item ('like the subject') the combined responses were 'I really like Biology (*or* Physics)' and 'I quite like Biology' (*or* Physics). chi^2 test.

8.3.8 Reasons underpinning differential views of undergraduate biology students

In order to explore which of the perceived characteristics of physics might be contributing to its lack of general popularity amongst biologists, regression analysis was performed using the responses to the initial item about overall attitude to physics ('How do you feel about physics?') as the dependent variable and the more detailed items about physics as a series of independent variables. Examination of the most significant associations indicated that the biology students who liked physics also thought it was interesting ($p<0.001$) and rejected the idea that it is boring ($p<0.001$). They also thought that it was easy ($p<0.001$). There were a weaker, but still statistically significant, associations between liking physics and the ideas that it is a boys subject ($p<0.05$) and that it employs 'everyday' words ($p<0.05$). Other individual ideas were not significantly associated with a liking for physics by the students on the Biology Programme of Studies.

8.4 DISCUSSION

The results of this section of the present study reveal the attitudes of undergraduate students to physics compared with their attitudes to biology. They show that undergraduate students, like Year 11 school students (Chapter 4) AS-level students (Chapter 7) and 'A' level students (Harvard, 1996), hold different views about biology and physics, implying that they do not regard science as an homogenous subject. Other than among students who had elected to study physics, physics was less popular than biology and was viewed, more specifically, as less interesting and less likely to contribute to medical and environmental problems.

The results also suggest possible reasons why undergraduate students who have elected to embark on different programmes of study, in English, biology or physics, feel positive or negative about biology and physics. The responses of the students who were following an English Programme of Study might be taken to represent the perceptions of a group of young adults who are academically able but who have not been exposed to science at an advanced level – those whose formal contact with science ceased at GCSE level. Such students tended to like biology more than physics. This distinction did not appear to be based on a view that physics is academically more difficult or requires more work than biology, although such students did tend to think of physics, but not biology, as requiring mathematical ability. Instead, more of this group of students regarded biology as interesting, and more rejected the idea that it is boring.

Undergraduate students on the Physics Programme of Study, those have elected to buck the trend and study physics at undergraduate level, liked their subject. This was despite the fact that few of them found physics easy and many considered that their subject carries a high workload. Almost all of these students acknowledged that physics requires ability in mathematics – this did not appear to have acted as a deterrent to this group of students. There may have been some forward thinking among physics undergraduate, because most of them believed that a qualification in physics rather than biology offers a greater variety of employment opportunities.

As might be expected, almost all of the biology undergraduate students liked their subject. This was reflected in their feeling that biology was interesting, although not necessarily easy. There was a big difference in the biologists' view of the requirement for mathematical ability for the two subjects; only a quarter thought this was needed for biology but almost all thought that it was needed for physics. Professional biologists might dispute this view – data transformation and statistical analysis form an integral part of many aspects of contemporary biology (Tariq, 2002). Furthermore, there is a call for biology to become more quantitative, to reflect the analytical requirements of modern biological techniques (Biotechnology and Biological Sciences Research Council, 2003). Biology undergraduates also tended to think that biology, as opposed to physics, had the potential to solve environmental and medical problems. Perhaps linked to this, they thought that biology was generally more 'relevant' to everyday life.

In one sense, undergraduate students on a Biology Programme of Studies represent those who, having chosen a science track in tertiary education might, at some stage in their academic career, have considered choosing physics. One way of increasing the student uptake of physics, then, might be to persuade a subset of intending biologists to pursue physics. This notion is re-enforced by the results of the cluster analysis, which produced two distinct groups among the biology students. Comparison of the responses of the two groups of biologists to individual questionnaire items showed that they did not differ much in their views about biology; both groups felt positive about many aspects of biology. What did distinguish the two groups was their attitudes to physics. So, one group tended to dislike physics, to find it boring and reject the ideas that it could contribute to a solution to environmental and medical problems. The other group, in contrast, liked physics, found it interesting and felt that it could offer solutions to environmental and medical problems. These students, being positive about physics, might be seen as having been 'persuadable' towards studying it.

Appendix 8.1

Cover Sheet for the Undergraduates Questionnaire

What do you feel about the sciences?

We are doing a large study in order to explore what people's perceptions of the sciences, Biology and Physics, are. We would like to know your opinion.

About you

Your age.........

Male/Female............

Your Degree Course (eg. F303)

....

Is your degree a BA or BSc?

....

Your year of study (1,2,3or 4) ....

Your A-level subjects and results or equivalent

Subject	Grade
1	......
2	......
3	......
4	......
5	......

Would you consider yourself to be an Artist or a Scientist? ....

If your parents work, what are their occupations?

1 ....

2 ....

APPENDIX 8.2

Distribution of responses of undergraduate students on different programmes of study (English, Biology and Physics) to questionnaire items about Biology and Physics

Appendix 8.2 Distribution of responses of undergraduate students on different programmes of study (English, Biology and Physics) to questionnaire items about Biology and Physics

	Views About Biology (% affirm)	*P* *Wilcoxon*	Views About Physics (% affirm)	Views About Biology (% affirm)	*P* *Wilcoxon*	Views About Physics (% affirm)	Views About Biology (% affirm)	*P* *Wilcoxon*	Views About Physics (% affirm)
Nature of the subject									
Like the subject	41	*0.001*	15	40	*0.001*	95	96	*0.001*	22
Interesting	76	*0.001*	32	65	*0.001*	97	97	*0.001*	39
Boring	17	*0.001*	55	27	*0.001*	13	1	*0.001*	44
Academic demands of subject									
Easy	4	*0.001*	3	23	*0.001*	8	15	*0.001*	1
Remembering facts rather than understanding	19	*ns*	17	52	*0.001*	3	15	*ns*	12
Lots of work	60	*ns*	69	68	*ns*	83	71	*0.05*	64
Good at maths	12	*0.001*	90	5	*0.001*	93	23	*0.001*	91
Relevance and benefits of subject									
Irrelevant to everyday life	14	*0.05*	21	23	*0.05*	17	7	*0.001*	17
Help solve environmental problems	59	*0.001*	36	67	*0.05*	75	84	*0.001*	28
Help solve medical problems	92	*0.001*	49	95	*0.001*	85	98	*0.001*	62
Lots of different jobs	68	*ns*	60	62	*0.001*	88	88	*0.001*	65
Well-paid jobs	23	*ns*	35	37	*ns*	47	18	*0.001*	39
Types of student									
More a boys subject	1	*0.001*	23	2	*0.001*	48	1	*0.001*	27
More a girls subject	4	*ns*	0	23	*0.001*	0	6	*ns*	0
People who don't mix well	5	*0.005*	10	5	*ns*	17	2	*0.001*	15
Communication of subject									
Uses lots of difficult words	40	*ns*	46	47	*0.01*	27	39	*0.01*	32
Uses everyday words with different meanings	8	*0.001*	15	10	*0.05*	33	8	*0.001*	13

The percentages show the proportion of undergraduate students in each cohort who affirmed the idea, giving either 'I strongly agree' or 'I agree' responses. In the case of the first item ('like the subject') the combined responses were 'I really like Biology (*or* Physics)' and 'I quite like Biology (*or* Physics)'.

EXPLORATION OF TEACHERS' VIEWS ABOUT WHAT INFLUENCES STUDENTS' ATTITUDES

Chapter Nine

9.1 INTRODUCTION

Research into school students' attitudes to the different sciences discussed in Chapter 4 shows that as students progress through secondary school their interest in, and attitudes towards, the different sciences change. The results indicate that students enter secondary school with an equal liking for biology and physics, perhaps not even distinguishing between them, but rather thinking in terms of science. However, as the students move to Key Stage 4 (National Curriculum Years 10-11) their attitudes change. So, whilst attitudes to biology remain fairly stable, attitudes to physics become increasingly negative.

Research has found that teachers are crucial agents of change in perceptions. For example, it has been found that teachers' beliefs are precursors to change in students' attitudes (Ajzen and Fishbein, 1980; Crawley and Koballa, 1992; Pajares, 1992; Battista, 1994). This situation raises a number of questions. For example, to what extent are teachers aware of what students think about the science subjects, and are they aware of what turns many school students away from or towards the different subjects. Also, to what extent are teachers in tune with students' opinions about science? Teachers, as the frontline practitioners, are in a position to attempt to forestall the development of negative views about physics. In order to do this it is important that teachers are aware of the underlying reasons for student's attitudes.

With this knowledge they can then attempt to work towards rectifying the problem. However, although teachers are in a position to influence their students, to do this successfully, they need to know which aspect of their students' thinking needs influencing.

The aim of this section of the present study, therefore, was to explore the views of teachers about why students tend to remain attracted to biology, but increasingly reject physics. The main aim was to determine the extent to which science teachers are in tune with what students are thinking.

In order to do this a Delphi technique was used. This is commonly defined as a method of systematic solicitation and collection of judgements on a particular topic through a set of carefully designed sequential questionnaires. The principle behind the Delphi study is that it aims to improve group decision-making by seeking opinions without face-to-face interactions (Smith and Simpson, 1995). This is a technique by which the views of a group of experts can be gathered and refined by re-iterative questioning of the experts. Initially, the views of a group of experts, teachers in this case, are sought about a particular issue. In this instance an open-form questionnaire was used to gather the perceived teachers views about the characteristics of biology and physics that they think may impact on students' opinions. These views were summarised and categorised. These categories were then used to construct a second, closed-form questionnaire. The questionnaire asked the same group of teachers to indicate how important they felt that certain perceived characteristics were in influencing students' attitudes to physics. This allowed the views of teachers to be ranked and the importance they attached to the various characteristics to be compared to those of students themselves.

9.2 METHODS

The method chosen for eliciting the teachers' views was a two-stage Delphi study similar to those used in curriculum-based explorations (Haussler *et al*, 1980; Smith and Simpson, 1995).

9.2.1 Contacting Schools

A list of mixed gender, community comprehensive schools were obtained from a database of NorthWest schools held in the Department of Physics at the University of Liverpool. This section of the study involved teachers from 10 schools that were mixed gender, community comprehensive schools. The first questionnaire was designed in consultation with others involved in this research and on the basis of experience of designing the previous questionnaires. Approval for the study was sought and gained from the head teachers of each school. Names of the science teachers in the schools were obtained from the heads of the science departments in each school. Individual science teachers were then contacted by letter and asked to complete the first questionnaire (Figure 9.1). The total number of teachers contacted was 86. Of the 86 contacted, 46 responses (53%) were received. On the basis of the responses to the first questionnaire, a second questionnaire was then designed and sent out to the 46 teachers that had responded to the first questionnaire; 24 (52%) responses were received back. The minimum number for a Delphi panel is ten and there is a reduction in error and improved reliability with increased group size up to thirty, after which there is no further benefit of increased numbers (Cochran, 1983). Thus, the number of respondents obtained in the present study was within the acceptable range for a Delphi study.

9.2.2 Design and structure of the questionnaires

The Delphi study consisted of two questionnaires. The first was an open questionnaire with four items that asked teachers to construct four lists of their ideas about why secondary students might find biology and physics attractive or unattractive. Two versions of this questionnaire were designed to neutralise any possible carry over effect from one item to the next. Half of the teachers were sent one version, the other half were sent the other version. In one version the biology lists were requested first; in the other version the physics questions were asked first. In addition, in the first version the items about what might make the subject unattractive were first whereas in the other version the items about what might make the subject attractive were first. An example of the wording of the item is shown in Figure 9.1.

Figure 9.1 Example of first questionnaire

Please list as many different reasons as you can that you feel might make **PHYSICS ATTRACTIVE** to **SCHOOL STUDENTS**
Please list as many different reasons as you can that you feel might make **PHYSICS UNATTRACTIVE** to **SCHOOL STUDENTS**

In the actual questionnaire the box for students' response was large. Bold text is shown as in the actual questionnaire. One page of the questionnaire contained items about physics, as above; the other page contained paralleled items about biology

The first questionnaire was sent to individual teachers with a covering letter and a stamped addressed envelope for returning the completed questionnaire.

Teachers' responses to these questionnaires were then used to generate a set of statements for the second questionnaire. This was done by collecting the responses into four lists, of reasons for students finding biology or physics attractive or unattractive. The ideas within each list were then grouped into similar themes. Finally, generic descriptors were devised to embrace the ideas within each theme. These descriptors were then used to formulate the items in the second questionnaire. The items took the form of statements and teachers were asked to tick a box to indicate whether they thought that a perceived characteristic was 'very influential', 'quite influential', 'a bit influential' or 'not at all influential' in making either biology or physics attractive or unattractive. An example of the layout and response options to one item in the second questionnaire is shown is Figure 9.2. The complete lists of items are shown in Figure 9.3. This second questionnaire was sent out to those teachers who had replied to the first questionnaire with a stamped addressed envelope for them to reply.

The responses of the second questionnaire that were received back from the teachers were coded according to whether the teacher felt the statement was 'very influential', 'influential', 'a bit influential' or 'not at all influential'.

Figure 9.2 Example of a second questionnaire closed item

Whether students feel physics is an **abstract subject** is			
☐	☐	☐	☐
Very influential in making Physics unattractive	Quite influential in making Physics unattractive	A bit influential in making Physics unattractive	Not at all influential in making Physics unattractive

Figure 9.3 List of statements about perceived characteristics that may influence students' views about physics and biology

BIOLOGY Attractive

Whether students feel biology **is easy** is

Whether students feel biology **is relevant to their everyday life** is

Whether students feel biology **is well taught** is

Whether students feel biology **offers good career prospects** is

Whether students feel biology **is interesting** is

Whether students **'get on' with the teacher** is

Whether students feel biology **does not need mathematics** is

Whether students **like the practical work** is

PHYSICS Attractive

Whether students **like the practical work in** physics is

Whether students feel physics **is challenging** is

Whether students **like the mathematical aspects of** physics is

Whether students feel physics **is well taught** is

Whether students feel physics **is interesting** is

Whether students **'get on' with the teacher** is

Whether students feel physics **has a low workload** is

Whether students feel physics **has good career options** is

Whether students feel physics **is relevant** is

Figure 9.3 (Contd)

BIOLOGY Unattractive

Whether students think biology **involves difficult language** is

Whether students think biology **involves too much work** is

Whether students think biology **is too hard** is

Whether students think biology **is a girls subject** is

Whether students **dislike practical work** is

Whether students think biology **involves difficult language** is

Whether students **get on with the teacher** is

Whether students think biology **is taught badly** is

Whether students think biology **is boring** is

Whether students think biology **offers good career prospects** is

Whether students think biology **is relevant** is

PHYSICS Unattractive

Whether students think physics **involves difficult language** is

Whether students feel physics **is not well taught** is

Whether students think physics **is difficult** is

Whether students **don't like the practical work** is

Whether students feel physics is **not relevant to their everyday life** is

Whether students feel physics **offers poor career prospects** is

Whether students feel physics **is boring** is

Whether students feel physics **is a male subject** is

Whether students feel physics **is a mathematically based subject** is

Whether students feel physics is an **abstract subject** is

Legend: Bold text is shown as in original questionnaire

The second questionnaire had a coversheet (Figure 9.4) that requested some personal information about the teachers. It asked teachers to tick category boxes which elicited their gender, age range, number of years teaching and which subjects (physics and/or biology) they taught at Key Stages 3 and 4. The final question on the coversheet asked the respondents what their original degree subject was.

Figure 9.4 Wording of the coversheet

About yourself

We would like to find out if different groups of teachers hold different views. To enable us to do this, please would you give us a few details about yourself. Naturally, these details will be kept confidential. Please just tick the appropriate boxes.

Your gender ☐ male ☐ female

How many years have you been teaching? ☐ less than 6 ☐ 6-10 ☐ 11-15 ☐ 16-20 ☐ 21+

How old are you? (leave blank if you prefer) ☐ Less than 25 ☐ 26-30 ☐ 31-40 ☐ 41-50 ☐ 50+

Do you teach physics subjects to Years 7-9? ☐ yes ☐ no

Do you teach physics subjects to Years 10-11? ☐ yes ☐ no

Do you teach biology subjects to Years 7-9? ☐ yes ☐ no

Do you teach biology subjects to Years 10-11? ☐ yes ☐ no

What is the main subject of your degree? ☐

9.3 RESULTS

9.3.1 Analyses and presentation of results

For presentation, the statements that made up the different sections of the first, open form questionnaire were classified according to whether the statements dealt with 'perceived academic characteristics of the subject', 'perceived benefits of the subject', or 'perceived teaching processes'.

The results of the second, closed form questionnaire are presented in two ways. Firstly, the percentages of teachers who felt that characteristics were 'very influential' and, in addition the combined percentages of teachers who felt that they were either 'very influential' or 'quite influential' to a student's feelings about a subject are displayed. These percentages are compared with some of the results obtained from the study that explored students' own ideas about the characteristics of biology and physics (Chapter 3). The data for this study of students' views were captured over a different time period and in different schools from those used in the present teachers' study, so are shown for general cross-reference only. In most cases the data shown are the combined percentages of students who 'strongly agreed' or 'agreed' with a statement, for example, that 'physics is interesting'. Secondly, in order to get an idea of the differences between teachers' views of the importance of various factors for the different subjects, comparisons have been made between the mean scores for biology and physics. The results of the comparisons of teachers' and students' views can be seen in section 9.4, figures 9.12-9.15

9.3.2 Results from the first, open-form questionnaire

The responses received from teachers were grouped into four lists, those characteristics that teachers thought made biology attractive and unattractive, and those that made physics attractive or unattractive to students. The complete lists are shown in appendices. Similar ideas within each of these lists were then pooled into categories. These categories, together with example statements from teachers are shown in Figure 9.6. These were used to construct the second, closed-form questionnaire.

Figure 9.6 Example of statements from teachers about why biology may be attractive to students

'Perceived benefits of subject'

"Relates to real life"
"Deals with real, living things"
"Applications in the real world"

'Perceived academic demands of subject'

"It is the easiest of the three sciences"
"Requires fewer concepts to understand"
"Context is often seen as more interesting"
"Think they will find out more about own body"
"Attractive careers"
"Many career paths"
"No maths"
"Conceptual nature of content"
"Less abstract"

'Perceived teaching processes'

"Like the teacher"
"Confidence in teachers"
"Teacher style and personal"

9.3.3 Results from the second, closed form questionnaire

In the second, closed form questionnaire teachers were asked to score the importance of various characteristics in making biology and physics attractive and unattractive to students. Combination of the responses of all teachers allowed the characteristics to be assigned a perceived relative importance. In order to rank the importance of the characteristics mean scores were calculated, a 'very influential' response being scored as 4, and a 'not at all influential' response as 1. Where the same reasons had been raised for making biology and physics attractive or unattractive, their mean scores were compared using a paired sample t-test.

How do teachers rate perceived characteristics of biology and physics in making them attractive to students?

Figure 9.6 Mean scores of characteristics perceived by teachers

Statements	**Biology** (Mean score)	**Physics** (Mean score)	**P- Value** (Paired sample t test)
Attractive because it is taught well	3.29	3.38	*ns*
Attractive because it is interesting	3.38	3.21	*ns*
Attractive because they like the practical work	2.88	3.08	*ns*
Attractive because it offers good careers	2.42	2.96	.016
Attractive because they get on with the teacher	3.33	2.83	.001
Attractive because it relates to everyday life	3.25	2.83	.005
Attractive because it involves maths		3.25	
Attractive because it is easy	3.08		
Attractive because there is no maths	2.83		
Attractive because of its low workload		2.13	
Attractive because it is challenging		2.04	

Mean scores were calculated by summing very influential responses as 4, 'quite influential' responses as 3, 'a bit influential' responses as 2 and 'not at all influential' responses as 1. Thus, higher values of mean scores indicate that characteristics were thought to be important to students by teachers. P values were calculated by paired t test $p < 0.05$ is taken as statistical significance

There was a common opinion amongst teachers that students find biology and physics attractive if it is taught well and if it is interesting. However, the ability of the subject to relate to everyday life and whether the students get on with the teacher were significantly more influential in making biology attractive than physics. In comparison, teachers felt that the involvement of mathematics made physics attractive to students, although presumably only to those students who enjoyed mathematics. The perceived challenge of physics and the low workload of physics were not thought to be influential in making physics attractive. The actual proportions of teachers holding these views are shown in Figure 9.8

What do teachers think makes biology attractive to students?

Figure 9.7 Teachers' views on the influence of various factors in making biology attractive to school students

	Teachers	
	Very influential (%)	**Very or quite Influential (%)**
Academic characteristics		
Relevant	29	96
Interesting	54	83
Easy subject	25	83
No mathematics	21	67
Benefits		
Good job prospects	8	42
Teaching process		
Get on with teacher	42	92
Well taught	46	83
Practical classes	13	75

Most of the teachers thought that the fact that biology could be seen as relevant to everyday life made biology attractive to students. Similarly, most of the teachers thought that students viewing the subject as interesting was an influential factor in attracting students to biology. Some of the characteristics of biology raised by teachers concerned effort or ability on the part of students.

Many of the teachers felt that the perception that biology was easy attracted students. Teachers thought that the perception that biology did not involve high-level mathematics made it attractive to students

Only about two fifths of the teachers thought that good job prospects attracted students to biology. The students' relationship with the teacher, and the quality of teaching were both thought to be influential in the popularity of biology by most of the teachers. Three quarters of the teachers also thought that practical classes enhanced students' opinion of biology.

What do teachers think makes physics attractive to students?

Figure 9.8 Teachers' views on the influence of various factors in making physics attractive to school students

	Teachers	
	Very influential (%)	**Very or quite influential (%)**
Academic characteristics		
Interesting	25	96
Involves mathematics	33	92
Relevant	21	63
Not much work	13	33
Challenging	0	29
Benefits		
Good job prospects	29	68
Teaching process		
Well taught	46	92
Get on with teacher	29	54
Practical classes	25	83

Almost all of the teachers thought that if students view physics as interesting, they will be attracted to it. Many of the teachers felt that the use of mathematics in physics might attract students to physics. Two thirds of the teachers also thought that if students viewed physics as relevant, it would attract them. About a third of the teachers thought that a perception of physics as requiring only a relatively low workload would attract students. A quarter of the teachers felt that students might be attracted by the challenge of physics.

When it came to possible future benefits to individual students, two thirds of the teachers thought that if students associated good employment prospects with physics, they would be attracted to the subject.

Teachers also saw the teaching process as influencing students' opinions of physics. A high proportion of the teachers raised the idea that physics could be made attractive by good teaching and, to a lesser extent, by a good relationship between student and teacher. The practical aspects of physics teaching were also thought to be attractive to some student

How do teachers rate perceived characteristics of biology and physics in making them unattractive to students?

There were statistically significant differences in what teachers thought made physics and biology unattractive to students. For example, it can be seen that teachers thought that a perception of biology and physics being boring was influential in the students finding the subject unattractive; this was significantly more for physics than for biology. The unattractiveness of physics was thought to be most influenced by the difficulty of the subject, how well it is taught, its lack of relevance to everyday life, the requirement for mathematics and because it is abstract.

Figure 5.9 Mean scores of characteristics perceived by teachers

Statements	Biology	Physics	P- Value (Paired sample t test)
Unattractive because it involves maths		3.67	
Unattractive because it is boring	3.13	3.63	.003
Unattractive because it is difficult	2.46	3.46	.001
Unattractive because it is abstract		3.25	
Unattractive because it is not taught well	2.96	3.13	*ns*
Unattractive because it is not relevant to everyday life	2.42	3.13	.000
Unattractive because they don't get on with the teacher	2.79	2.96	.043
Unattractive because it uses a difficult language	2.46	2.79	.029
Unattractive because of the practical work	2.25	2.46	*ns*
Unattractive because of career	2.38	2.38	*ns*
Unattractive because it involves too much work	2.38		
Unattractive because it is a boys subject		2.29	
Unattractive because it is a girls subject	2.00		

Mean scores were calculated by summing very influential responses as 4, 'quite influential' responses as 3, 'a bit influential' responses as 2 and 'not at all influential' responses as 1. Thus, higher values of mean scores indicate that characteristics were thought to be important to students by teachers. P values were calculated by paired t test $p < 0.05$ is taken as statistically significant.

What do teachers think makes biology unattractive to students?

When it came to the academic demands of the subject, most teachers thought that students' perceptions of biology as a boring subject would deter them from electing to study biology. Similarly, about three quarters of the teachers thought that the idea that biology is difficult would deter students from studying it. In part, this may be because of the specialist vocabulary used in biology. About half of the teachers thought employing difficult words would make biology unattractive students. About a third of the teachers thought that a high workload would give students a negative attitude to biology. About a third of the teachers thought that practical classes might deter students from studying biology.

Figure 9.10 Teachers' views on the influence of various factors in making biology unattractive to school students

	Teachers	
	Very influential (%)	**Very or quite influential (%)**
Academic Characteristics		
Boring subject	33	79
Difficult subject	13	75
Difficult words	58	88
Not relevant	8	46
Lots of work	21	38
Girls subject	4	29
Benefits		
Poor job prospects	8	50
Teaching process		
Badly taught	29	67
Don't get on with teacher	33	46
Practical classes	8	38

Teachers' responses to the perceived benefits of the subject showed that about half of the teachers thought that if biology appeared irrelevant to students, students would be deterred from studying biology. About half of the teachers thought that poor employment prospects would discourage students from studying biology.

A quarter of the teachers thought that if biology was perceived as a girls' subject it would deter students from studying it.

Teachers again raised issues about the teaching of biology. Over half of the teachers thought that poor teaching style and about a third of the teachers thought that a bad teacher-student relationship would deter students from studying biology.

What do teachers think makes physics unattractive to students?

Teachers thought that, if students perceive physics as a difficult subject, it deters them from finding physics attractive with 100% perceiving this to be 'very influential' or 'quite influential'. Similarly 100% of the teachers thought that the mathematical aspects of physics were 'very influential' or 'quite influential' in causing students to find physics unattractive.

Figure 9.11 Teachers' views on the influence of various factors in making physics unattractive to school students

	Teachers	
	Very influential (%)	**Very or quite influential (%)**
Academic Characteristics		
Difficult subject	46	100
Involves mathematics	67	100
Boring subject	68	96
Abstract subject	42	88
Difficult words	4	75
Not relevant	29	83
Boys subject	4	42
Benefits		
Poor job prospects	8	38
Teaching process		
Badly taught	38	75
Don't get on with teacher	38	58
Practical classes	4	46

Three quarters of teachers felt that the difficult words used in physics played a part is making physics unattractive to students. Most teachers also thought that student's perceptions of physics as a boring subject would deter them from finding the subject attractive.

9.4 DISCUSSION

All of the ideas included in the second, closed-form questionnaire were raised by teachers themselves in the first round of the Delphi study. The second round of the study was designed to gain insight into the ways in which a group of experts, teachers in this case, would prioritize the factors they had identified. These factors raised by the teachers fell into three categories; the content and demands of the subject, the longer-term employment prospects, and modes and standards of teaching.

9.4.1 Teachers' views about the factors affecting students' feelings about physics

The first category of reasons, 'content and demands of the subject', encompass the ease, use of mathematics, interest and relevance of the subject. The results indicate that teachers view the perceived ease of the subject as an important factor in making the subject attractive or unattractive to students. It is likely that high ability students who find the subject easy are more likely to be attracted to the subject than those who find it difficult. This was reinforced by teachers' beliefs that the difficulty of the subject was a major factor in making physics unattractive to students. The mathematical content of physics was also identified as a key factor in making physics attractive or unattractive to students. This again suggests that those students who are able at mathematics are more likely to be attracted to physics than less mathematically able students.

9.4.2 Teachers' views about the factors affecting students' feelings about biology

The results indicate that teachers view the perceived ease of the subject and whether the subject is perceived as interesting as an important factor in making the subject attractive or unattractive to students. In addition to this the perceived relevance of the subject was believed to be influential in making biology attractive to students. This may be because the school students find the human body, the 'facts of life', and personal health issues such as smoking and drinking- as relevant to their everyday lives.

Both students' relationship with the teacher and the quality of teaching were thought to be important to the popularity of biology by most of the teachers. In the introduction to this study it was highlighted that science, and especially physics, teaching is facing problems due to a shortage of graduates becoming teachers. The result of this shortage is that in many schools subjects are being taught by non-specialists without a formal qualification in the subject. If, as a large proportion of the teachers suggest, the quality of teaching is important in influencing attitudes towards the subjects then this is an important factor to consider when looking at factors affecting students' attitudes.

9.4.2 Comparison of teachers' and school students' views about what makes biology and physics attractive

Some of the ideas raised by the teachers were compared with the views of students themselves, although these students were not from the same school as the teachers and so statistical analysis was not possible. From this it is possible to identify which factors teachers think are important, and how students themselves feel these about these factors. Thus, it will provide an insight into the degree to which teachers' and students' views aligned (Figure 9.12)

Most of the teachers thought that the perceived relevance to everyday life made both biology and physics attractive to students. However, half the students in the previous section of this study (Chapter 4) felt that biology was relevant to everyday life, compared to a third who held this view for physics. This could be a factor in deterring students from studying physics, and teachers seem aware of this.

Most teachers thought that if students view physics and biology as interesting, they would be attracted to it. Unfortunately, the previous study had shown that although about two-thirds of the Year 7 students do think of physics as interesting, only a third of the Year 11 students thought this. In comparison, more of the students in both Year 7 and Year 11, about two thirds, viewed biology as interesting.

Some of the characteristics of biology raised by teachers as influencing students' attitudes concerned effort or ability on the part of students. Many of the teachers felt that the view that biology was easy attracted students, although fewer of the students, a fifth, in fact thought that biology was easy. Since just over half of students like, biology there are apparently other important factors in attracting students to this subject.

Figure 9.12 Comparison of teachers' and school students' views about what makes biology attractive.

Biology Attractive	Teachers: Very important (%)	Teachers: Very or quite important (%)	Students: Year 7 (%)	Students: Year 11 (%)
Academic characteristics				
Relevant*	29	96	40	52
Interesting	54	83	67	63
Easy subject	25	83	20	20
No mathematics**	21	67	54	68
Benefits				
Good job prospects	8	42	66	60
Teaching process				
Get on with teacher	42	92		
Well taught	46	83		
Practical classes	13	75		

Wording of student questionnaire items were *'The things I learn in Biology do not relate to my everyday life' and **'You need to be good at maths to do Biology'. The figures given are the percentages of students rejecting these ideas, to compare with the ideas raised by teachers.

Figure 9.13 Comparison of teachers' and school students' views about what makes physics attractive.

Physics Attractive	Teachers: Very important %	Teachers: Very or quite important %	Students: Year 7 %	Students: Year 11 %
Academic Characteristics				
Interesting	25	96	63	36
Involves mathematics	33	92	34	64
Relevant	21	63	39	38
Not much work	13	33	9	5
Challenging	0	29		
Benefits				
Good job prospects	29	68	62	59
Teaching process				
Well Taught	46	92		
Get on with teacher	29	54		
Practical classes	25	83		

Teachers thought that the perception that biology did not involve high-level mathematics made it attractive to students; indeed, more than half of the students did in fact think that biology did not need mathematics. Perhaps surprisingly, due to previous research highlighting which found that mathematics has been one of the key factors in turning students away from physics, many of the teachers felt that the use of mathematics in physics might attract students to physics, and an increasing number of students appreciated that physics does involve mathematics. It may be that those students who enjoy mathematics are attracted to physics due to its highly mathematical nature.

Most teachers thought that if students view physics as interesting, they will be attracted to it. Unfortunately, the previous study had shown that although about two-thirds of the Year 7 students do think of physics as interesting, only a third of the Year 11 students thought this. If students are not interested in physics by the time they reach Year 11, this may result in low numbers taking up the subject at A-level.

Certain statements about physics but not biology such as workload and the challenge of physics, were originally raised in the first stage of this present study. About a quarter of the teachers thought that a perception of physics as requiring only a relatively low workload would attract students, although few students actually held this view of physics. A quarter of the teachers felt that students might be attracted by the challenge of physics. Again this lends itself to the suggestion that students with higher academic abilities are attracted to physics, in this case because it offers them a challenge.

The previous study of students' perceptions of biology and physics had not included aspects concerned with the actual teaching process, for reasons of sensitivity. However, the teachers themselves raised such issues. So, the students' relationship with the teacher, and the quality of teaching were both thought to be important to the popularity of biology by most of the teachers and equally a high proportion of the teachers raised the idea that physics could be made attractive by good teaching and, to a lesser extent, by a good relationship between student and teacher. Research has found that teachers are crucial in influencing students' attitudes towards a particular subject (Ajzen and Fishbein, 1980; Crawley and Koballa, 1992; Pajares, 1992; Battista, 1994)

The practical aspects of physics and biology teaching were also thought to be attractive to some students. However, it was not evident from this study whether teachers think this applies equally to males and females. The aspect of practical classes was previously raised in Chapter 6 which looked at gender differences in attitudes to physics and biology. Here, it was highlighted that differences occurred in males and females views of practical elements of their science courses with males preferring the practical elements of the curriculum more than females. This is further supported by research which states that the curriculum favours males more than females with physics often being taught in an abstract rule dominated way with lots of practical work which is more suited to boys than girls (Murphy, 1990). This evidence may suggest that a more differentiated approach to the use of practical work may be necessary.

In the previous study more than half of the students had thought that biology offered a variety of career prospects compared with two thirds of the students when asked about physics. This is supported by the teachers, with significantly more teachers feeling that the awareness of good career prospects was more likely to attract students to study physics than biology It would appear, however, due to numbers declining this would suggest that the career opportunities that physics offers is not enough to sway students negative attitudes, as the uptake of physics courses continues to decline. This may also indicate that teachers' views may over-emphasize the importance that students place on careers prospects on subject choice.

9.4.3 Comparison of teachers' and school students' views about what makes biology and physics unattractive

Most teachers thought that students' perceptions of biology as a boring subject would deter them from electing to study biology, although the previous study had shown that only about a fifth of students actually think biology is boring. Most teachers also thought that student's perceptions of physics as a boring subject would deter them form finding the subject attractive. A quarter of the students in year 7 found physics boring suggesting that when the topics were new to the students they found them interesting. However it has long been a complaint of the curriculum that the revisiting of topics year in year out starts to switch students off the subject may be observed in the increase to 50% of year 11 finding physics boring.

Figure 9.14 Comparison of teachers' and school students' views about what makes physics unattractive

	Teachers		Students	
	Very important	Very or quite important	Year 7	Year 11
	%	%	%	%
Academic Characteristics				
Difficult subject	46	100	44	67
Involves mathematics	67	100	34	64
Boring subject	68	96	24	50
Abstract subject	42	88	27	23
Difficult words	4	75	42	44
Not relevant	29	83	22	33
Boys subject	4	42	11	19
Benefits				
Poor job prospects	8	38	7	8
Teaching process				
Badly Taught	38	75		
Don't get on with teacher	38	58		
Practical classes	4	46		

Three quarters of the teachers thought that the idea that biology is difficult would deter students from studying it, although only a third of students think that biology is difficult. All teachers thought that if physics is perceived as a difficult subject by students it deters them form finding physics attractive. The previous section of the study showed that although under half of the students in Year 7 thought that physics was a difficult subject this increased to nearly two thirds of the students by year 11 suggesting that as they progress through the years the difficulty of the subject is an area that starts to put people off physics.

Figure 9.15 Comparison of teachers' and school students' views about what makes biology unattractive

	Teachers		Students	
	Very important	Very or quite important	Year 7	Year 11
	%	%	%	%
Academic Characteristics				
Boring subject	33	79	20	19
Difficult Subject	13	75	33	33
Difficult words	58	88	53	44
Not Relevant	8	46	28	22
Lots of Work	21	38	54	70
Girls subject	4	29	8	8
Benefits				
Poor job prospects	8	50	9	11
Teaching process				
Badly Taught	29	67		
Don't get on with teacher	33	46		
Practical classes	8	38		

The specialist vocabulary used in biology, was thought by about half of the teachers, to be an important factor in making biology unattractive students, and about half of the students thought that biology did employ difficult words. In comparison about three quarters of the teachers felt that the difficult words used in physics played a part in making physics unattractive to students. However only about half the students felt that physics used difficult words. It may, however, be that the students are not finding the words difficult but rather that they are used in different contexts to the usual everyday words.

The lack of relevance of the subject was thought to be an important factor in making the subjects unattractive to the students. Half of the teachers thought that if biology appeared irrelevant to students, students would be deterred from studying biology although, in fact, only about a quarter of students thought that biology was not relevant. Over three quarters of teachers rated this as an important factor in influencing negative views from students' towards physics. Over a third of students in Year 11 stated that they thought physics was not relevant to everyday life. This has been raised in previous research which showed that there is a failure to link the content of school science to students' everyday lives (Osborne and Collins, 2000). From this present research it has therefore emerged that teachers are aware that the relevance of the subject to the students everyday lives is important in making science attractive to the students and yet is apparent that the relevance is not getting through to some students. This raises the question about whether the teachers are aware that students are not seeing the relevance or whether the curriculum is such that although the teachers understand that it is important they are not getting a chance to demonstrate this. It is evident that missing, for far too many students, are the vital ingredients - "relevance and greater autonomy" (Osborne and Collins, 2000).

It has also been highlighted that there are notable gender differences in the opinions about the everyday usefulness and relevance of science, although this was not immediately obvious in the research carried out in this study. Osborne and Collins (2000), found that boys highlighted the use of aspects of physics far more in a group discussion than girls who 'were notable for their virtual absence' from discussions about the relevance of the subject.

About a third of the teachers thought that a high workload would put students off biology. About half of the younger students and about three quarters of the oldest students thought that biology did require lots of work.

A quarter of the teachers thought that if biology was perceived as a girls' subject it would deter students from studying it but the previous study had shown that few students actually think this way about biology. A similar question of gender came up with the perception of physics but with the thought that it was a boys' subject. Over a quarter of the teachers thought that if physics was perceived as a boys' subject it would deter students from studying it. However, in a similar way to biology, few students actually did think this way.

Similarly all of the teachers thought that the mathematical aspects of physics were very important or quite important in causing students to find physics unattractive. This was supported by the previous studies findings that a third of the year 7 students thought that you had to be good at mathematics to do physics compared to nearly two thirds of year 11 students. It is believed that the mathematical detail involved in the physics develops through the years of secondary schooling causing more students to find physics unattractive in the later years

In Chapter 4 (figure 4.11) the possible characteristics influencing attitudes were categorised according to the importance to the students. The characteristics that were classified as proximal to students, such as the perception that it is easy and interesting were also rated as being important in making physics and biology attractive by the teachers. In a similar way, the teachers and students felt that if perceived as boring and irrelevant the subject would not be attractive to the students. This suggests that the teachers are in tune with many of the factors that turn students away from or towards physics and biology. This being the case, further questions arise such as - are the teachers, who appear to be aware of the factors contributing to students opinions, acting to try and forestall such negative attitudes developing or are there other factors out of the control of teachers such as the curriculum content that need addressing.

The findings of this present research have highlighted significant differences in attitudes between physics and biology at various levels of education from secondary school age through to undergraduates. In addition to this the research into teachers' opinions about factors affecting students' attitudes support these findings. The results emphasise a need for education programmes and activities to try to correct this situation. The final chapter of this thesis will evaluate the factors that affect attitudes to science and suggest ways in which perceptions may be improved.

Appendix 9.1

Example of the letter sent to request teacher participation

Dear ....

School Students' Views about Physics and Biology

We are writing to ask for your help. We do appreciate how busy teachers are, so we would especially value a few moments of your time.

We are conducting a research programme to investigate why students are reluctant to select physics at school, and hence why there are relatively few applicants for physics at university. We have already explored the views of secondary school students and undergraduate students; we now wish to score the opinions of experts – why you think that school students might like or dislike physics.

This section of the research will take the form of a 'Delphi' study. We will ask you, the experts, for two bits of information. Firstly, we will ask you to list your own ideas of why physics and biology may be popular or unpopular with school students. From this information we shall construct a list with the ideas of all of the experts we have consulted Secondly, we will return this overall list to you and ask you how important you think each factor is to school students. From this we will make a final prioritised list. Naturally, we will send you a copy of this final list, for your information and for your comments, should you wish to make any.

Most of our research is completely anonymous; we do not know who completed which questionnaire. For this section of the research we shall need to keep some form of identification, so that we can proceed with the second phase of the study (and so that we can enter your name in a 'draw' for a book token). This is why the questionnaire is numbered. However, all results will be kept confidential and no views or opinions will be ascribed to individuals. We are interested in the overall views of the expert community, not of particular individuals.

We would ask you to complete the questionnaire individually (i.e. please do not discuss it with colleagues) - it is your own views about why school students might like or dislike physics and biology that we are interested in.

It is important for the quality of the results that we get a high return rate. We shall supply stamped addressed envelopes for you to return the questionnaires at each stage. In addition, we shall put the names of the participants in a draw for a £50 book token. All we ask is a few minutes of your time to give us your thoughts.

We do hope that you will feel able to join in this project.

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Enclosed: Questionnaire 1
Stamped addressed envelope

Appendix 9.2

First questionnaire sent out to teachers

Number [ ]

SCHOOL STUDENTS VIEWS ABOUT PHYSICS AND BIOLOGY
Please answer the questionnaire individually (i.e. do not discuss with colleagues)

Please list as many different reasons as you can that you feel might make **PHYSICS ATTRACTIVE** to **SCHOOL STUDENTS**

-
-
-
-
-
-
-
-

Please list as many different reasons as you can that you feel might make **PHYSICS UNATTRACTIVE** to **SCHOOL STUDENTS**

-
-
-
-
-
-
-
-

Please list as many different reasons as you can that you feel might make **BIOLOGY ATTRACTIVE** to **SCHOOL STUDENTS**

-
-
-
-
-
-
-
-
-
-

Please list as many different reasons as you can that you feel might make **BIOLOGY UNATTRACTIVE** to **SCHOOL STUDENTS**

-
-
-
-
-
-
-
-
-
-

APPENDIX 9.3

Responses to the first questionnaire

Biology attractive

Relevance of subject

They can apply their knowledge to real life (eating breathing seeing)
Has relevance to them and their life
It relates to life
Relevant to own self
See as more relevant
Relevance
Linking subject matter to pupils lives
About ourselves
Know about how your own body works
Lessons are interesting and relevant to life
Students can relate to biology C.F other sciences
Relates to real life
They learn about themselves "Me"
Deals with real, living things
Relevance to every student
Applications in the real world
Learning about your body - easy to relate to and visualise
It is perceived as the easiest of the sciences
It is directly related to themselves
Human biology is relevant - they all have a body even if they don't use their brain
The subject relates to one's own body
Think they will find out more about own body

Ease of the subject

It is the easiest of the three sciences
Requires fewer concepts to understand
Students may succeed with higher grades - Supported by anecdotal evidence from siblings
It's the easiest science
Many take biology as a science option to balance arts subjects a they find it easier to understand than physics and chemistry
Science can be "non maths and so I can do it"
Feel that success is attainable in this subject
User friendly
Can revise without a great depth in understanding
" Easier of the three sciences" - a great deal of it is common knowledge
Can be seen as the easy option when C.F to the other sciences
Easier to understand
Easier than physics - easier to visualise many parts
It is perceived as the easiest of the three sciences
Easily assessable

Careers

Attractive careers
Many career paths
Attached to prestigious careers
Employment opportunities
To be a doctor - well paid
To help others - cures/transplants etc
Essential for certain career choices
Many career opportunities including medicine, nursing and lots of medical related careers
I would make a difference in this field
Relevance to a job
Biotechnology and genetics are seen as providing a good job opportunity
As a degree subject/ part of allows many more career paths as a result
It is seen as a career path to medical jobs - nursing and dentistry etc

Interest

Context is often seen as more interesting
Think they will find out more about own body
Interesting
Lots of news, interesting developments in biology cloning
Interesting
Fun well planned lessons
i.e. human biology therefore more interesting/relevant.
Interesting to know how all-living organisms are interconnected

Practical work

Involves some practical work
Practical work more relevant
May do exciting experiments
Simple apparatus in practicals
Dissections
Appropriate practical work
Possibility of chopping up freshly dead things
Field trips
Practical
Working outdoors
Like the field work
Like experiments

Maths

Lack of maths
No maths
Conceptual nature of content
Less abstract
Don't need to know a lot of formula

Teachers

Like the teacher Where its taught well Confidence in teachers Teacher style and personality Involvement of pupils in the lesson Notion of being aware and au fait with self Taught well in primary - better foundation in secondary Taught from primary school Previous interest in the subject

Resources

Supported by a wider? Range of resources They can relate information from many sources- e.g family life/papers/TV/internet/ magazines to topics studied Lots of high quality videos available

Topics

Technologically advanced subject area eg PCR, genetic fingerprinting, genetech. Human biology Eco – issues Living things Working with living things Animals Find out how human body works Understand how organisms work

Other comments

Sex Pictures . learn long word, label picture Colouring Reproduction lessons Visual/Auditory/Kinaesthetic approaches Use of ICT Equally open to boys and girls Better image - not the same 2 old man image of physics Allows for a number of investigations which may not have one particular answer Some of the subject matter - makes them laugh i.e. the reproduction modules (especially the boys) Hands on Has many links with other subjects i.e. seen as useful to take at GCSE and A level to help with GCES?A level PE Good exam results in this area Fits with other non science as courses so allows a wider subject combination

Biology Unattractive

Gender

Boys may see it as mainly attracting females - this could prove attractive to boys who want to mix with girls! Perceived as a girls subject Perceive as a girls subject by some boys

Lack of relevance

It may have the perception that it does not lead directly to employment other than medicine Not going to use any biological knowledge in their future jobs Maybe linked to underpaid/stressful job- nursing Parts of it aren't seen as relevant - eg Plants and ecology Not interesting to them Not useful in terms of their future Pupils see it as boring Perceived lack of relevance

Difficulty

Tremendous knowledge needed Questions too wordy Too much writing Lots to remember Lots of detail Too much reading Too much learning Requires note taking Weaker students find it demanding Higher concepts esp. genetics and biochemistry Belief that students already know a great deal can lead to apathy Don't like scientific enquiry Some of the concepts at AS level are very difficult and off putting to some students Still regarded as a science and science is hard Higher level GCSE biology requires a lot of thought Answers are not always obvious

Terminology

Long scientific names Involves some difficult terminology which they must use Do find the technical terms difficult and as with all the science disciplines, we find pupils simply cannot be bothered to learn , familiarise, re-read work Do find the technical terms difficult Too many long words to learn Facts cannot just be learnt and regurgitated

Boring

No excitement Perceive it as boring Boring lessons without practical

Practicals

Difficulty in obtaining data from investigations school lab level Not that many practical activities to do at school any more most of hem have been vetoed due to health and safety requirements Don't like experiments Squeamish Afraid to study human body Put off by dissection/blood etc Smelly Practical work difficult Don't like chopping things up Don't like blood or fluids Limited practical equipment - can't do exciting things that have heard about Dissections Don't like field work Don't like dissecting organs/creatures

Topics

Many students quiet enjoy learning about the human body but find plants boring (as a biologist I find this particularly upsetting I don't like plants Green plants Reproduction lessons???? Classification They may perceive that they have already studied a particular topic Some mathematical processes are difficult e.g statistics Lack of general background knowledge not easy to visualise food webs if they don't know what they animals look like

Teachers

Don't like the teacher Teacher / pupil relationship poor Teacher making subject abstract and so difficult to access Where it is taught badly Where it is taught by non specialists Lack of teacher interest Teacher style and personality Pitching material above pupils heads No feed back in books from marking etc No variety in lessons Boring texts

Other reasons
No role models
Lack of sufficient examples to establish concepts clearly
National curriculum
Experience of biology only as a school subject
Requires them to build on previous knowledge and learn more detail on topics covered earlier
Again, British don't value science only money driven movie stars pop stars soap stars and half wited morons who can kick a ball
KS4 repeats KS3 (not as badly as physics though)
Lack of practical work Not a great deal of practical now available and results can be unpredictable
Apply the words cruel and disgusting with no real consideration to the issues involved
Don't like science
Too many exceptions to the rule
A lot of overlap with chemistry

Physics attractive

Careers

Future job prospects / good career opportunities
Lot's of money if you are really good
It gives openings to careers in engineering etc.
Future career
Useful in certain career choices
Well paid jobs where the skills are rewarded ie not teaching – students can go into sales and earn big money – why bother with engineering

Practicals

Appropriate practical work in lessons
Lots of hands on expt which can be done
Practical work
There are many interesting practicals/experiments in electricity etc
Use of certain equipment such as Lasers and lenses which can catch the imagination
Physics practical work tends to work
Involves practical work
Practical work is an integral part
Practical
Things work
Easy to set up

Challenging

Less straight learning more working out
It's a challenge
Cutting edge science
Gain a deeper personal understanding
Challenging 3
Challenging
Have to think your way through

Relevance

Lessons can explain everyday things like electricity to them
Explains things that parents cannot help with e.g. astronomy, silicone technology etc
Relevance to their everyday life especially comparison to things they observe e.g. energy transfer shown using a film such as Independence Day
Application to real life
Reflects an interest already had
Explains why the universe is at it is
Developing an understanding of how things work
Stimulating - not always true that we have answer
Applicable to real life
Some vocational relevance for lower level courses e.g. car mechanics
Relevance
Useful subject

Maths

Calculations Things put more meaning to the usefulness of maths, like getting results from graphs, being accurate Those that have a high capability in maths find it very easy Those that are mathematically inclined like the logical nature of the subject I'm good at maths Those who are good at maths perceive it as straightforward It is like maths but with understanding They enjoy mathematics and problem solving

Teacher

Teacher / pupil relationship positive at GCSE Like the teacher Quality of teacher and teaching Confidence in teachers The teacher's style and personality Teacher enthusiasm for their subject (physics)

Status

Status Valued as a high status subject Feather in their cap

Liking for the Subject

It can include astronomy/ space studies which most students find intriguing/inspiring Intellectually stimulating and rewarding Interesting Enjoyable Liking of topic areas Curiosity about the unknown They have a passion for physics

Low workload

Not too much reading to do No extended writing needed It does not have the workload associated with other subjects It is less descriptive than other subjects with the emphasis being on concepts I find it easy to understand Find it easy at GCSE Answers to test questions are often short answer therefore pupils with weak written skills may be able to do well

Academic package

Need as part of package to proceed to HE Taken as part of physics/maths package at a level Needed for medicine/post A2 courses Complements other science biology and chemistry

Problem solving

Problem solving Like logical approach to problem solving

Topics

Big science e.g. astronomy The study of everything that has ever existed Predictive power of laws The hardware Space Electronics Modern topics I like Stephan Hawkins ideas on the universe Lots of new developments which have enabled other sciences like biology to progress e.g. electron microscope

Type of subject

Utilise contemporary technology – IOP advancing physics I like the clear cut ideas/ black or white A lot of cross curricular some topics/subjects are similar Visual Auditory Kinaesthetic approaches Uses of ICT Similar ways of looking at things

Easy exams

Good exam results Pupils do like to see good sets of results and these are usually obtained in physics History of success within the school

Unattractiveness of Physics

Mathematical basis of the subject

Too many maths problems
Formulae
Many students do not feel confident in mathematics
They feel they cannot handle the equations
A lot of maths involved – puts people off
Too much maths
Very put off by maths content e.g. transforming formulae graphs
Too many equations
It is like maths
Too much maths
Requires some mathematical skill
Requires logical thinking
Involves problem solving
They see it as all formulae
They don't like manipulating numbers
Maths
Suitable only for mathematicians
Too much theory
Mathematics aspect of physics
Find application of maths difficult

Subject is Boring

Very conceptual
Boring
Perception that it is boring
Boring
It is thought to be boring
No excitement
Boring texts
Boring lessons without practicals
Not very compelling c.f. to chemistry and biology in that the practical investigations are very dull and may appear boring
Not very compelling c.f. to chemistry and biology in that the practical investigations are very dull and may appear boring
Boring

Career Prospects

Don't know where they're heading – career prospects
Jobs on offer – " what can I do with physics"
Do not really know the careers it can lead to or do not find them interesting if they do
The job prospects of this subject are not well advertised
A career that leads to a good wage is not one associated with the anorak image of a physicist
Can earn more money doing doss courses (or is that msdos)
You get a job then an English history, sociology graduate will be your boss and say "I never understood that at school"
They see no reward – they only want to learn the minimum of subjects to get a job

Lack of relevance

Do not see it as relevant to life
It's not obvious
They see no relevance in their lives
What's the relevance? No relevancy
Not see relevance of subject
Seen as irrelevant don't see how it relates to real life
The subject content appears to be irrelevant to everyday situations for less academic pupils
Don't see how it relates to real life
Perceived lack of relevance
Not enough application to everyday life
Not relevant for many jobs

Too Hard

Is often seen as being a " hard/difficult" subject
Too hard
It is seen as too hard
I find it difficult to remember
Perceived as difficult
Too difficult
Easier options
Seen as inaccessible/difficult
Pupils see physics as too hard/too mush work
Feel they cannot handle the working out aspects of physics

Abstract

Too abstract Concepts are difficult to understand Not enough practical work Cannot visualise the reality Too much theory Weaker pupils find it demanding, application of abstract concepts difficult Too dry Involves abstract concepts Too abstract in places

Teachers

Poor teaching, without enthusiasm or understanding Untrendy teachers – often seen as eccentric/geeky Teacher/pupil relationship poor Taught badly by non specialists under current dual award curriculum arrangement Taught badly in primary schools therefore nothing to really build on Teacher making subject abstract, therefore difficult to access The teacher's style and personality Pitching material above students' heads No variety in lessons Not making physics fun Lack of teacher interest Taught by biologists

Gender

Perceived as boys subject Idea of physics being a male subject usually more boys than girls in the groups Still considered a boys topic particularly if its taught in a mixed group It is perceived as being mainly for males Boys take over girls Seen as male only

Types of people

It has the image of being for geeks or nerds It can be perceived as Elitist Image problems _ stuffy old man with long beards

Topics

Calculations Electronics Generally do not like scientific enquiry Not seen as in vogue topic

Resources

High cost of equipment leads to rationing of it during practical Under resourced Lack of good quality videos and animations to explain more abstract work

Other reasons

Don't like laboratories Straightforward fact does not suit the more abstract thinker/learner British society doesn't value physics and physicists unless they're directly creating wealth (the British are plebs) Done it all before – ks4 repeats ks3 largely Practical is dry compared with practical in chemistry and biology as nothing happens Same as when their grandparents were at school No recognition that man will soon be going to mars and Lara croft is popular Pedestrian National Curriculum - No time lots of targets No feedback in books from marking etc No interest from parents No role models Distrust of science (atom bomb factor) Old equipment breaking down Experience of physics only as a school subject Practical work is an integral part Poorly written exam papers set image problems in context National decline in employment prospects – you can earn much more managing MacDonald's than working in engineering

APPENDIX 9.3

Example of the second questionnaire sent out to teachers

Factors that might make Biology ATTRACTIVE

How **INFLUENTIAL** and **IMPORTANT** do you think each of these factors are in making **BIOLOGY ATTRACTIVE** to some **SECONDARY STUDENTS**?

Whether students feel biology **is easy** is

☐	☐	☐	☐
very influential in making biology attractive	quite influential in making biology attractive	a bit influential in making biology attractive	not at all influential in making biology attractive

Whether students feel biology **is relevant to their everyday life** is

☐	☐	☐	☐
very influential in making biology attractive	quite influential in making biology attractive	a bit influential in making biology attractive	not at all influential in making biology attractive

Whether students feel biology **is well taught** is

☐	☐	☐	☐
very influential in making biology attractive	quite influential in making biology attractive	a bit influential in making biology attractive	not at all influential in making biology attractive

Whether students feel biology **offers good career prospects** is

☐	☐	☐	☐
very influential in making biology attractive	quite influential in making biology attractive	a bit influential in making biology attractive	not at all influential in making biology attractive

Whether students feel biology **is interesting** is

☐	☐	☐	☐
very influential in making biology attractive	quite influential in making biology attractive	a bit influential in making biology attractive	not at all influential in making biology attractive

Whether students **'get on' with the teacher** is

☐	☐	☐	☐
very influential in making biology attractive	quite influential in making biology attractive	a bit influential in making biology attractive	not at all influential in making biology attractive

Whether students feel biology **does not need mathematics** is

☐	☐	☐	☐
very influential in making biology attractive	quite influential in making biology attractive	a bit influential in making biology attractive	not at all influential in making biology attractive

Whether students **like the practical work** is

☐	☐	☐	☐
very influential in making biology attractive	quite influential in making biology attractive	a bit influential in making biology attractive	not at all influential in making biology attractive

Factors that might make BIOLOGY UNATTRACTIVE

How **INFLUENTIAL** and **IMPORTANT** do you think each of these factors are in making **BIOLOGY UNATTRACTIVE** to some **SECONDARY STUDENTS?**

Whether students think biology **involves difficult language** is

☐	☐	☐	☐
very influential in making biology unattractive	quite influential in making biology unattractive	a bit influential in making biology unattractive	not at all influential in making biology unattractive

Whether students think biology **involves too much work** is

☐	☐	☐	☐
very influential in making biology unattractive	quite influential in making biology unattractive	a bit influential in making biology unattractive	not at all influential in making biology unattractive

Whether students think biology **is too hard** is

☐	☐	☐	☐
very influential in making biology unattractive	quite influential in making biology unattractive	a bit influential in making biology unattractive	not at all influential in making biology unattractive

Whether students think biology **is a girls subject** is

☐	☐	☐	☐
very influential in making biology unattractive	quite influential in making biology unattractive	a bit influential in making biology unattractive	not at all influential in making biology unattractive

Whether students **dislike practical work** is

☐	☐	☐	☐
very influential in making biology unattractive	quite influential in making biology unattractive	a bit influential in making biology unattractive	not at all influential in making biology unattractive

Whether students think biology **involves difficult language** is

☐	☐	☐	☐
very influential in making biology unattractive	quite influential in making biology unattractive	a bit influential in making biology unattractive	not at all influential in making biology unattractive

Whether students **get on with the teacher** is

☐	☐	☐	☐
very influential in making biology unattractive	quite influential in making biology unattractive	a bit influential in making biology unattractive	not at all influential in making biology unattractive

Whether students think biology **is taught badly** is

☐	☐	☐	☐
very influential in making biology unattractive	quite influential in making biology unattractive	a bit influential in making biology unattractive	not at all influential in making biology unattractive

Whether students think biology **is boring** is

☐	☐	☐	☐
very influential in making biology unattractive	quite influential in making biology unattractive	a bit influential in making biology unattractive	not at all influential in making biology unattractive

Whether students think biology **offers good career prospects** is

☐	☐	☐	☐
very influential in making biology unattractive	quite influential in making biology unattractive	a bit influential in making biology unattractive	not at all influential in making biology unattractive

Whether students think biology **is relevant** is

☐	☐	☐	☐
very influential in making biology unattractive	quite influential in making biology unattractive	a bit influential in making biology unattractive	not at all influential in making biology unattractive

Factors that might make PHYSICS ATTRACTIVE

How **INFLUENTIAL** and **IMPORTANT** do you think each of these factors are in making **PHYSICS ATTRACTIVE** to some **SECONDARY STUDENTS**?

Whether students **like the practical work in** physics is

☐	☐	☐	☐
very influential in making physics attractive	quite influential in making physics attractive	a bit influential in making physics attractive	not at all influential in making physics attractive

Whether students feel physics **is challenging** is

☐	☐	☐	☐
very influential in making physics attractive	quite influential in making physics attractive	a bit influential in making physics attractive	not at all influential in making physics attractive

Whether students **like the mathematical aspects of** physics is

☐	☐	☐	☐
very influential in making physics attractive	quite influential in making physics attractive	a bit influential in making physics attractive	not at all influential in making physics attractive

Whether students feel physics **is well taught** is

☐	☐	☐	☐
very influential in making physics attractive	quite influential in making physics attractive	a bit influential in making physics attractive	not at all influential in making physics attractive

Whether students feel physics **is interesting** is

☐	☐	☐	☐
very influential in making physics attractive	quite influential in making physics attractive	a bit influential in making physics attractive	not at all influential in making physics attractive

Whether students **'get on' with the teacher** is

☐	☐	☐	☐
very influential in making physics attractive	quite influential in making physics attractive	a bit influential in making physics attractive	not at all influential in making physics attractive

Whether students feel physics **has a low workload** is

☐	☐	☐	☐
very influential in making physics attractive	quite influential in making physics attractive	a bit influential in making physics attractive	not at all influential in making physics attractive

Whether students feel physics **has good career options** is

☐	☐	☐	☐
very influential in making physics attractive	quite influential in making physics attractive	a bit influential in making physics attractive	not at all influential in making physics attractive

Whether students feel physics **is relevant** is

☐	☐	☐	☐
very influential in making physics attractive	quite influential in making physics attractive	a bit influential in making physics attractive	not at all influential in making physics attractive

Factors that might make PHYSICS UNATTRACTIVE

How **INFLUENTIAL** and **IMPORTANT** do you think each of these factors are in making **PHYSICS UNATTRACTIVE** to some **SECONDARY STUDENTS**?

Whether students think physics **involves difficult language** is

☐	☐	☐	☐
very influential in making physics unattractive	quite influential in making physics unattractive	a bit influential in making physics unattractive	not at all influential in making physics unattractive

Whether students feel physics **is not well taught** is

☐	☐	☐	☐
very influential in making physics unattractive	quite influential in making physics unattractive	a bit influential in making physics unattractive	not at all influential in making physics unattractive

Whether students think physics **is difficult** is

☐	☐	☐	☐
very influential in making physics unattractive	quite influential in making physics unattractive	a bit influential in making physics unattractive	not at all influential in making physics unattractive

Whether students **don't like the practical work** is

☐	☐	☐	☐
very influential in making physics unattractive	quite influential in making physics unattractive	a bit influential in making physics unattractive	not at all influential in making physics unattractive

Whether students feel physics is **not relevant to their everyday life** is

☐	☐	☐	☐
very influential in making physics unattractive	quite influential in making physics unattractive	a bit influential in making physics unattractive	not at all influential in making physics unattractive

Whether students feel physics **offers poor career prospects** is

☐	☐	☐	☐
very influential in making physics unattractive	quite influential in making physics unattractive	a bit influential in making physics unattractive	not at all influential in making physics unattractive

Whether students feel physics **is boring** is

☐	☐	☐	☐
very influential in making physics unattractive	quite influential in making physics unattractive	a bit influential in making physics unattractive	not at all influential in making physics unattractive

Whether students feel physics **is a male subject** is

☐	☐	☐	☐
very influential in making physics unattractive	quite influential in making physics unattractive	a bit influential in making physics unattractive	not at all influential in making physics unattractive

Whether students feel physics **is a mathematically based subject** is

☐	☐	☐	☐
very influential in making physics unattractive	quite influential in making physics unattractive	a bit influential in making physics unattractive	not at all influential in making physics unattractive

Whether students feel physics is an **abstract subject** is

☐	☐	☐	☐
very influential in making physics unattractive	quite influential in making physics unattractive	a bit influential in making physics unattractive	not at all influential in making physics unattractive

DISCUSSION

Chapter Ten

10.1 INTRODUCTION

The present study has compared attitudes to physics with attitudes to biology in a number of different respondent groups. The aim has been to determine more detailed aspects of respondents' negative views about physics with the hope that such information may enable education strategists and practitioners to modify the content and delivery of physics, making it more acceptable. The significance of the views of the various respondent groups has been discussed in individual chapters. The purpose of this final chapter is to acknowledge some of the limitations of the research tasks employed, to look at the general findings, to look at the implications of continuing negative attitudes and to look at the possible actions to ameliorate the unpopularity of physics.

10.2 LIMITATIONS OF PRESENT STUDY

There are a number of issues to raise about the sampling techniques and methodologies used in this research. The time scale limitations of this study have meant that cross-age rather than a longitudinal studies have been carried out. The research, therefore, does not track the changing opinions of individual students. Rather, it reveals on a population basis how the constructions of students' attitudes to two science subjects, physics and biology, differ over the period of secondary and tertiary education.

One of the most important issues with this type of research is how representative of the population the results are. It is clearly not possible to test everyone in the target populations, so techniques to sample people who are representative of the population as a whole were chosen. This means that the findings of this study can only be applied to the population of England. The sampling technique used was appropriate in terms of time and resources. However, there are weaknesses in opportunity sampling. Opportunity sampling can produce a biased sample, as it may be a temptation for the researcher to choose people from their own social and cultural group. To try eliminate cultural and social biases and to introduce a degree of homogeneity in the sample, the schools used in the sections of the study that concentrated on secondary education were selected from non-religious, mixed gender, community comprehensives.

A further problem with opportunity sampling is that it may only gain responses from participants who want to take part. This problem may have been an issue in the Delphi study, when some participants did not respond to the first and second questionnaire leading to a self-selected sample. However, this problem probably did not have a major influence in the other sections of this study, where all students present completed the questionnaire.

This present study relied heavily on questionnaire methods in order to obtain numerical data for large respondent groups. Although a qualitative method would give a deeper understanding of individual views a quantitative approach was considered the most suitable for cross sectional comparisons. In addition, however, qualitative methods in the form of interviews were used to inform the content of the quantitative studies. These data, although not included in this report, confirms its main findings and is currently being developed into a research paper.

10.3 GENERAL FINDINGS OF PRESENT STUDY

10.3.1 Changes in students' constructions across secondary schooling

A key finding of the present research is that students hold different detailed views about biology and physics, implying that they do not regard science as a homogenous subject. Previously, there has been little research on the divide within the science subjects. The present study has formally confirmed teachers' impressions that over the period of secondary schooling a decreasing proportion of students expressed a liking for physics, and shown that fewer thought it was interesting and more thought it was boring. These changes did not apply to biology. There was also an increasing view that the study of physics, but not biology, required mathematical skills. Fewer students thought that physics, compared with biology, could contribute to the solution of medical or environmental problems. The results also identified that suggestions that physics might offer good employment prospects did not influence students' attitudes towards physics. Further, data reduction analysis suggested that the oldest group of students distinguished between physics and biology in terms of their general characteristics – to the detriment of physics. It was possible to identify associations between some of these factors and a general liking for physics. With school students, for example there was an association between a liking for physics and the view that it is interesting, easy and relevant to everyday life.

Clearly, a multitude of factors influence such student attitudes (Woolnough 1994a, 1994b; de Almeida, Leite and Woolnough, 1998). Some of these factors are dependent on individual students themselves, such as their abilities and, perhaps connected, innate preferences. These factors are not immediately amenable to influence by educators. Other factors are less dependent on individuals' characteristics, but are also outside the influence of the school; the social status and remuneration of professional scientists are examples. Nevertheless, some factors are under the influence of the learning environment – the curriculum, the quality of teaching, the variety of teaching methods, and the degree of encouragement received by students. The items on the questionnaire reflected some of these factors.

Perhaps the most obvious factor raised by students was the link between finding a subject boring and perceiving it as being difficult. Indeed, there is evidence that the perception of a subject as being difficult tends to result in the development of a generally negative attitude to that subject (Rennie and Punch, 1991). Furthermore, students tend to choose for further study those subjects in which they anticipate they will be able to perform well (Rennie and Punch, 1991). The challenge here, then, is to make physics less daunting to school students while retaining its essential nature.

10.3.2 Reasons underpinning students' constructions

It was also found that one of the major influences on whether students find a subject interesting, itself a major factor in determining whether a subject is liked, appears to correspond with whether they perceive it as 'relevant'. This was given as a reason for finding both biology and physics interesting. In a complementary manner, 'lack of relevance' was given as a reason for finding them boring.

The two most predominant reasons for finding both biology and physics interesting were the content of the curriculum and the practical nature of the subjects. The former appears to play a greater role in making biology interesting to students; the latter seems to play a greater role in convincing students that physics is interesting. Certain topics were found to be inherently popular with certain students. However, with other students the same topics were found to be inherently unpopular. This suggests that expanding or removing certain topics from the curriculum might have little effect on the overall attitudes towards the subject because the very thing that attracts some students has an opposite effect on other students.

For both biology and physics, the results of the present study imply that students find practical exercises interesting, and that the dearth of such exercises is unpopular with some students. There has undoubtedly been pressure on teachers to reduce the extent of practical work (Hacker and Rowe, 1997), for a number of reasons. Firstly, it is time-consuming in the context of an overcrowded curriculum; coupled with an increased emphasis on the use of examination results as the indicator of educational 'success', as a result practical work may be getting reviewed and replaced with exam orientated teaching. Secondly, it requires expenditure for equipment and consumables and there are safety implications. In the case of biology, there are the additional issues of Home Office legislation and students' concerns about animal rights. Despite all this, most teachers would regret the need to decrease the extent of practical exercises. So, it is worth noting that cutbacks in practical work not only reduce opportunities for experiential learning, they might also influence the overall popularity of science subjects including physics.

10.3.3 AS-level students' constructions of biology and physics

In previous research it has been observed that A-level subjects are chosen partly on the bases of students' interest in them and the academic freedom afforded by them. Unfortunately in this context, it has been observed that the science subjects are perceived by students to offer the least academic freedom and interest (Watson *et al*, 1994). The work of Watson *et al* did not, however differentiate between the science subjects. Evidence from this section of the present study highlights that even students who have chosen not to follow a pathway into the sciences differentiate between biology and physics, and find biology more interesting than physics.

One of the main differences between perceptions of biology and physics among AS-level students was the perceived social benefits of the subject.

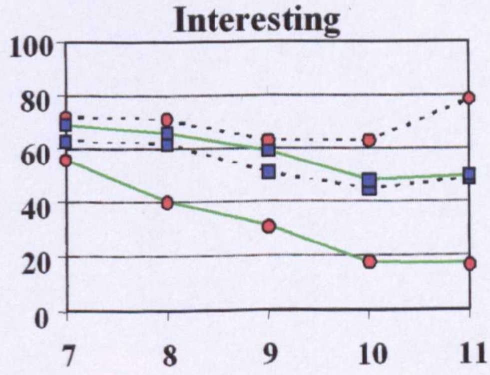
Substantially more students thought that biology had social benefits than physics. However, it appears that AS-level students are not yet aware of the social benefits of their subject at this point. In a similar way, students thought that biology involved significantly less maths than physics. Students at this level may not yet have come across the statistical analysis that forms an integral part of the A-level study. All examination boards now have to cover this mathematical element of the curriculum in response to calls for biology to become more quantitative, to reflect the analytical requirements of modern biological techniques (Biotechnology and Biological Sciences Research Council, 2003). It would be interesting to investigate the attitudes of AS-level students again in their second year of study, to establish whether a change occurs as they progress further into the A-level biology course.

10.3.4 Undergraduates' constructions of biology and physics

The findings from this section of the study highlighted that non-scientist Year 1 undergraduates perceive biology as more readily accessible than physics, and as having more immediate connections to everyday life. This may be because of the popularisation of biology in the popular electronic media such as television documentaries about wildlife and medical issues. These are attractively produced and 'concrete' in nature, in that the animals and plants are visible and colourful. In contrast programmes about some of the aspects of physics that students do find interesting, such as 'space' (Watson, 2000), might seem somewhat remote. In addition, the 'new biology' has become linked with medical diagnosis and treatment, areas that the lay public find intrinsically interesting. Indeed, more of the students on the English Programme of Studies thought that biology, rather than physics, could offer solutions to environmental and medical problems. To these non-scientists, then, physics is seen as less attractive, less interesting and less likely to offer solutions to human problems than is biology.

10.3.5 Males' and females' constructions of biology and physics

One of the most significant findings of this study is linked with the interest that secondary students showed towards the two sciences (Figure 10.1).



Most significant is the change in attitudes of the females towards physics compared to biology over the period of secondary schooling and the similarity of the males' attitudes towards both biology and physics. The attitudes of the females towards physics changed from just fewer than 60% to less than 20% between Year 7 and Year 11 of schooling. In comparison, although the males attitudes to physics did fall, the decrease was substantially less than for females. In addition the males attitudes to physics and biology by year 11 did not differ. One possible reason for such differences may be that females question their understanding more than males and hence rate physics as being more difficult and in turn less interesting than males do (Stadler et al, 2000).

However there are a number of deeper levels that could account for such differences in males and females attitudes that are dependent on the characteristics of individual students themselves. For example, Hogg and Vaughan (1998) have stated that there is a belief that the inbuilt personalities of males and females differ, and that these differences cannot be modified. In contrast, other authors emphasise the effect of gender differences being as a result of family backgrounds (Breakwell and Boardsell, 1992; Breakwell and Robertson, 2001). For example, Hutt (1972) states that gender differences in attitudes to science, rather than being intrinsic, are established early in life. Murphy (1990) found that it was experiences in early childhood that play an important part in developing attitudes to science. The environment, in which children have been raised, both at home and in the local community, may provide such experience. Kelly (1981) states that early socialization may lead girls away from science:

> *"By virtue of the toys they are given to play with, the hobbies they are encouraged in, household jobs they are asked to help with and the masculine image of science and scientists in books films and television."*

Others have identified the media exposure and advertising as a source differences in attitudes to science. The social status of professional physicists would be examples of this type of factor. (Hogg and Vaughan, 1998).

Other factors that might influence gender differences in attitudes to science are less dependent on individuals' characteristics. Lloyd and Duveen (1992, 1993) argue that gender categorisation and roles are implicit in the personal relationships prevailing in families, but in addition to this, school, as a social institution, makes gender explicit in all sorts of subtle ways, and thus legitimises it. This is supported by the findings of Hodson and Freeman (1983), who showed that science courses are structured in a male oriented way, with boats, cars and parachutes being used as typical examples.

Yet other factors that might influence males and females differentially are under the influence of the learning environment, for example, the content of the curriculum, learning and teaching methods, and the degree of encouragement received by students. If the people around us play an important part in developing our attitudes to science, then the attitudes of teachers towards girls' abilities in physics must also be important. Harding (1982) concludes that the individual behaviour and teaching style of a teacher may be more effective in influencing girls in their employment and choice of physical science than their gender.

In all of these factors, gender is a differentiating influence. If the previous examples contribute to the differences in constructions of biology and physics then one might imagine that females who have received less encouragement than boys at home or in school might not choose to pursue careers related to the physical sciences. Female students might anticipate that they would be regarded as of lesser status and have worse promotion prospects within the community of professional physicists.

10.4 IMPLICATIONS OF CONTINUING NEGATIVE ATTITUDES TO PHYSICS

It has been argued that if the decline in attitudes to physics during secondary school years, and which persists into tertiary education, is not addressed then the performance of the national economy, which is partially dependent on a vigorous scientific and technological background, will start to diminish (Roberts, 2002). A strong background in the field of science is thought to enhance the UK's international competitiveness, and physics must play a major role in this. In addition to this, it is argued, if the decline in attitudes continues, the general public, who require a level of scientific understanding in an increasingly scientific and technological society, will be denied empowerment as citizens (Jenkin, 2000).

One of the major problems with the current decline in the popularity of physics is that if the attitudes to physics continue to be low with the consequence that few students opt to study this subject at A-level and beyond, then university physics departments across the country will continue to suffer. This may produce two results. Firstly, if the numbers entering into the undergraduate level of study continue to decline, universities may opt to close physics departments. This situation is already occurring in some universities across the UK. Alternatively, the number of people eligible for research, or teaching will reach critically low levels. The dearth of physics graduates has already resulted in a shortage of secondary teachers qualified in physics, which in turn may aggravate the problem of the unpopularity of physics. As a consequence, school students in many cases are being taught physics by non-specialists. The result of this may be that students are taught with less enthusiasm and 'feel' for the subject, and will be less inclined to pursue physics to advanced level. For all of these interacting reasons, it is clear that steps must be taken to halt and reverse the decline in the popularity of physics.

10.5 POSSIBLE ACTIONS TO ADDRESS THE UNPOPULARITY OF PHYSICS

A main finding of this research has been that the decline, in terms of both general opinion and more specific views, to physics occurs at about Key Stage 4. If attempts are to be made to improve this negative change, then action needs to be taken prior to this stage.

In England, as in many other countries, the problem of few students electing to take physics at A-level and beyond is longstanding. Unfortunately, because the reasons underlying student choice are complex, the solution to this issue is unlikely to be simple. However, students do appear to be influenced by proximal factors, those in the classroom and here-and-now, so teachers do have opportunities to influence student thinking.

10.5.1 Reducing the mathematical image of physics

Interest was identified as the major factor in influencing whether a student liked or dislike the subject. One task, then, may be to make physics more interesting at the point of presentation, in the classroom. One strategy has been to teach physics, at the Key Stage 3 level at least, in a more descriptive, narrative form rather than in a mathematical form, attempting to reduce students' perceptions of it as a mathematical subject (Soloman *et al*, 1994). However, there will be those who argue that physics *is* essentially a mathematical science, and that to remove its mathematical basis is to betray its essence. Furthermore, there is a danger that successful inculcation of a more visual construction of physical phenomena in students' minds might hinder the later transition to a more mature understanding. It has been shown that misconceptions, which can be firmly entrenched, may not be entirely displaced by tuition (Ausubel, 1968), but rather that students may hold several different understandings of physical phenomena simultaneously (Maloney and Siegler, 1993). Even more extreme, it has been suggested that presentation of a 'simple', mechanistic model of physical phenomena may reduce students' motivation to replace it with a more scientific model (Curtis, 1994). To quote Fischler and Lichtfeldt (1992),

> *"Why should the student learn these new ideas [quantum mechanics in this case], if beforehand he has assured himself of all that which can be achieved with the help of the illustrative model?".*

Thus it may be that a 'spiral' curriculum, in which topics are revisited at various stages in an attempt to facilitate a maturation of thinking, may not only lead students to a judgement that the subject is boring (because it has been 'done' on previous occasions), but may actually hinder more advanced learning.

10.5.2 Increasing the perceived relevance of physics

Another option is to consider how physics, indeed science in general, could be better communicated to the general public (Office of Science and Technology/Wellcome, Trust 2000). It has been suggested that for effective communication, scientific knowledge should have obvious relevance, be helpful and useful, come from a trustworthy source, be relatable to other social knowledge and be communicated in an accessible manner (Fensham, 2000). Perhaps what is needed is even more examples of obvious 'relevance'. Students might be more convinced of the 'relevance' of physics by using, to an even greater extent, issues such as investigation of physical techniques and instrumentation involved in medical diagnosis and treatment, the importance of physical processes in modern technology (computers, mobile telephones and music-storage devices such as CDs, minidisks and MP3) as a starting point for curriculum physics. The increased and more gender-balanced uptake of application led A-level courses such as 'Advancing Physics' by the Institute of Physics and 'Salter Horners physics' indicates the potential value of taking this approach.

10.5.3 Inclusion of ethical considerations in the physics curriculum

Another way in which physics might be made more appealing to students is to include ethical aspects of physics. Furthermore, it may be an opportune moment to make such additions. There has been a call recently for a more comprehensive inclusion of the consideration of ethics within the school science curriculum. The thinking is that many advances in scientific understanding and application bring with them ethical quandaries, and that non-scientists should be equipped with the scientific information and ways of thinking sufficient to enable them to consider such issues. The inclusion of such ethical and social viewpoints in science is beginning to be addressed in the new curriculum changes proposed. One such change is '21st Century Science – the Science for Citizenship' which is currently undergoing trials in over 50 schools around the UK. Another possibility is to identify ethical dilemmas or controversies that could sit within the physics curriculum and use them, perhaps as a starting point for the consideration of curriculum science. As well as the familiar examples such as cost-benefit analysis of alternative sources of energy (including nuclear energy) in the light of the effects of carbon-based energy sources on global climate change, one might include more personal issues such as the possible personal and public health hazards of mobile telephone equipment. However, one problem with using controversial issues to introduce curriculum science is that many of them are transient; media coverage of certain issues quickly diminishes and other issues take their place.

10.5.4 Teaching physics through biology

Another possibility for increasing the popularity of physics is for science teachers to place more emphasis on interdisciplinary links, perhaps by raising, for example in *biology* lessons, circumstances in which physics is relevant to popular areas of biology.

10.5.5 Using an application-led approach

Perhaps one approach, even within the constraints of the National Curriculum, would be to emphasise even more the practical applications of physics, and to *introduce* each topic with problems relevant to students. This should be possible because physics is, in reality, relevant to contemporary issues. For example, just how is it that so much popular music can be crammed into miniature MP3 players, what are the dynamics of a football as it hits the crossbar, and exactly how is it possible to transmit pictures across the country using mobile phone technology? Following on from this idea of linking modern science in the real world with science in the classroom, Baldly (2002) has suggested that even our future scientists would be better prepared by a curriculum that reduced its factual emphasis and covered less, but uncovered more of what it means to practice science. Coles' (2002) findings suggest that the need for skills developed by opportunities to conduct investigative practical work, such as that required in the UK – the ability to interpret, present and evaluate evidence, the ability to manipulate equipment, are second to none yet with an overstretched science curriculum and tightening rules of health and safety the chances to develop these skills are fast diminishing.

When asked, teachers felt that good career prospects would influence whether student found the subjects attractive. Yet it would appear that this is a distal motivator to the students. If the awareness of career options was raised, with more links to industry, universities and other careers built into the science lessons this may positively influence students attitudes towards the sciences. In addition to this, as Roberts (2002) stated, the government needs to take action to prevent the 'brain drain' which means ensuring the research and development in science is promoted and rewarded financially.

The link between the perceived relevance of a subject and its attractiveness to school students may partly explain the success of the physics Standard Grade system in Scotland in terms of attracting students (Reid and Skryabina, 2002), since the curriculum was designed to be application-led, with examples of practical applications preceding an explanation of the underpinning theory (McCormick, 2000). It is easy to see how students would see such an approach as 'relevant', particularly if the examples chosen were related to student lifestyle.

10.5.6 Encouraging the missing half

As discussed previously, it is likely that personality differences between girls and boys may underpin the situation in which relatively fewer girls than boys are attracted to physics. It is reported that boys tend to be more independent, achievement-orientated and dominant, whilst girls are more people-orientated, socially responsible, friendly and co-operative (Reid and Skryabina, 2003) If this is the case, any particular method used by teachers will impact on one personality type more than the other. For example, girls may react more favourably to teaching that includes examples that are more concrete and related to human activity and experience, and so girls may benefit from a more contextual approach to teaching that may increase their interest in the subject (Qualter, 1993). Instead, physics is more often taught in an abstract, rule-dominated way, with lots of practical work which is more suited to boys than girls (Murphy, 1990) and which might have a more immediate resonance with male than with female students.

Ironically, in the present atmosphere of heightened sensitivity to 'political correctness' there might be problems in using strategies targeted specifically at females. Any attempt to use examples in which physical principles or phenomena are demonstrated and that might be of particular interest to females might be open to the accusation of gender stereotyping. Nevertheless, the issue of which topic areas might be of inherent interest to females, and which might persuade students of the 'relevance' of physics is worth exploring further in the attempt to recruit more females, and hence more students overall, to courses in physics. The way to provide females with more equal access to physics may be to recognise that, whether through inherent characteristics or early socialisation, they are different.

10.6 SUGGESTIONS FOR FURTHER WORK

The research carried out in this present study has concentrated on quantitative methods in order to obtain large respondent group data to enable cross-sectional comparisons to be made. Further research in the form of qualitative research would give a deeper understanding of individual views. During this present study, focus groups were carried out to inform the content of the quantitative studies. The qualitative information that they provided is enough to form the basis of further research. These data, although not included in this present study, confirms its main findings and is currently being developed into a research paper.

The research looking at teachers' views about students' constructs of physics and biology, did not allow, due to insufficient data, for comparisons of responses to be made between teachers from different science backgrounds, age and teaching experience. Further studies with larger numbers of teachers would allow possible differences to be identified.

In a similar theme, teachers' backgrounds, experience and age may influence students' attitudes. Early it was mentioned that as a consequence of having less physics teachers graduating, teachers from other subject areas are having to teach a subject which they do not specialise in. It is believed that this may influence their enthusiasm and confidence in teaching and thus may influence the students' attitudes towards a particular subject. Further research to identify whether such factors influence students' attitudes needs to be carried out.

10.7 CONCLUSIONS

Should we elect to exploit any of the factors identified in this chapter in an attempt to halt the decline in popularity of physics, it would be important to ensure that any changes made do not deter students who are already attracted to physics. In addition, there are issues about the essential nature of physics as defined by, for example, the physics research community. If the nature of physics taught at secondary, or even tertiary levels is altered to make it more attractive to students, there may develop an educational and intellectual gulf between the physics of professional physicists, and that of physics students.

This brings us back to the aims of science education that were initially discussed in section 1.3. The model of science education that originally suited the minority who chose to continue with science post-14 of their own accord was imposed on all school students with the introduction of 'science for all' (DES 1989). The economists' argument sees this as good move, as it would ensure an appropriate pre-professional form of training for the minority of today's youth who will become the scientists of tomorrow (Barnett 2001). Others believe that we should not be trying to impose science on students and that it has been this development that has been responsible for the undervaluing of science.

An over concentration on the detailed content of science may prevent students appreciating why Dalton's ideas about atoms, or Darwin's ideas about natural selection, are among the most powerful and significant pieces of knowledge we possess. Consequently, it is perhaps unsurprising that many pupils emerge from their formal science education with the feeling that the knowledge they acquired has no value and that the task of constructing any edifice of note was simply too daunting – the preserve of the boffins of the scientific elite (Millar & Osborne 1998).

The current phase of change that science education is facing, may offer answers to these issues through the development of a curriculum that genuinely meets the needs of all pupils, including the few who will enter into professional science. Ideally, such a curriculum will develop the skills and thought processes necessary for a scientist, and prevent any the gulf forming between the science of the professionals and that of the students, while also having the ability to develop 'scientific literacy' for all. Such a curriculum will require a new educational approach, one that moves away from knowledge delivery towards involving pupils more actively in engaging with scientific ideas and developing the skills necessary for appraising evidence, handling risk and uncertainty, and recognising social and other influences on decision making and research.

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