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STUDENTS' ATTITUDES TO LEARNING PHYSICS AT SCHOOL AND UNIVERSITY LEVELS IN SCOTLAND

by

Elena Skryabina

M.Sc. (Physics), St. Petersburg State University, Russia

A thesis submitted in part fulfilment of the requirements
for the degree of Doctor of Philosophy (Ph.D.)

Centre for Science Education, Faculty of Science
University of Glasgow

To my son Gleb

Abstract

The department of Physics of the University of Glasgow was concerned about losing students after the end of the level 1 Physics course. The current research project started as an attempt to find out the reasons for this, but moved to investigate attitudes towards Physics at several stages during secondary school and attitudes towards science with primary pupils.

Analyses of factors, which influence students' intentions towards studying Physics, were performed against the background of the Theory of Planned Behaviour, which interprets people's behaviour by considering three factors:

- attitude towards behaviour (advantages or disadvantages of being involved in the behaviour, e.g. studying Physics for Honours);
- subjective norm (approval or disapproval of important people towards engaging in the behaviour, e.g. parents, teacher, general norms of the society);
- perceived behavioural control (skills, knowledge, cooperation of others, abilities, efforts required to perform the behaviour).

Analysis of these factors revealed some reasons for students' withdrawal from Physics after level 1 and pointed to factors which may facilitate students' persistence in the subject.

A general analysis of level 1 and level 2 students' attitudes towards different aspects of the university Physics course revealed that the level 1 students' attitudes towards their university course of lectures and course of laboratories tended to be negatively polarised. Recommendations were suggested on the basis of the gathered evidence about how to make students' experience in university Physics more satisfactory for them.

The data obtained from the separate analyses of females' and males' attitudes towards university Physics course have shown that attitudes of females and males were similar. The only significant difference between level 1 females and males was found to be the

perceived behavioural control factor (students' attitudes towards course difficulty, attitudes towards work load in the course), which was significantly lower for females than for males.

Special attention in this work was given to the problem of university Physics laboratory practice. Possibilities to improve students' attitudes towards laboratory work were discussed. This could be done through introduction of

- pre-lab (aimed to consolidate students' grasp of the necessary background for performing the experiment) and
- post-lab (aimed to provide students with opportunity to apply the theory they have learned and skills they have obtained from doing laboratory work to solve everyday problems).

Examples of pre- and post-labs that were designed for the first term of the level 1 university Physics laboratory practice are given in the Appendix T.

The project was extended from the university to the school area where cross-age analyses (measurements at one time with pupils of different age) of pupils' attitudes towards Science/Physics lessons were performed. Pupils from upper Primary P6/P7 up to Higher S5/S6 were involved in the research. These analyses have shown that patterns of Scottish pupils' attitudes towards Science/Physics lessons are not linear with age: attitudes of pupils who were self-selected towards the subject were not always more positive than attitudes of lower level pupils:

- primary school pupils' attitudes towards science lessons were significantly more positive than attitudes of secondary S2 pupils;
- pupils doing Standard Grade Physics course were similar in their evaluations of Physics lessons at both S3 and S4 levels;
- at Higher Grade Physics pupils' attitudes towards science lessons were significantly less positive than attitudes of Standard Grade Physics pupils.

Pupils' attitudes towards Science/Physics lessons can be considered as a good indicator of pupils' reactions towards existing syllabuses in Science and Physics.

Special attention in this study was devoted to the so-called "problem of girls in Physics". Separate analyses of boys' and girls' interests towards Physics topics revealed that although boys and girls are equally interested in certain areas of the subject, there are areas in Physics where boys and girls interests are significantly different.

No differences were found in intensity of boys' and girls' interests towards suggested Physics topics at primary P6/P7 level, S3 and S5/S6 levels. At S2 and S4 levels a significant decline of girls' interests relative to boys interests was observed. S2 and S4 stages are decision making ones when pupils have the opportunity to select courses for the future.

It was also revealed that the ratio of boys to girls in Physics once established at S2 level remains unchanged through the years of Standard Grade and Higher Grade Physics courses. This may indicate that if the number of girls in Physics is an issue for concern then attention should be paid to the primary and, especially early secondary years to attract girls to Physics. School Physics courses in Scotland revealed a high retention rate of girls in Physics.

Analyses of preferred activities revealed that practical work is the most enjoyable activity in Science/Physics lessons for both girls and boys at every stage of schooling and studying the theory was found to be the least enjoyable activity at school for both genders at every age. The picture was almost the reverse with university Physics students.

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Introduction

According to the data from the Institute of Physics the number of new Physics graduates every year in the UK has remained fairly constant for more than a decade and is around 2 500. This situation has occurred in spite of the fact that the number of students going to university has more than doubled for the same period to over 1.5 millions (Physics World, 10, 99, p.3). For the same period of time, some significant changes have happened in Physics in Higher education in some European countries and in the USA. It is a general concern that their number of graduates in Physics has been falling. In the USA the number of students graduating with degrees in Physics has fallen significantly in recent years (Leath, 1998). In Germany, for example, the number of first-year Physics students had fallen from almost 10 000 to just 5 000 during the past seven years, and there has been an alarming drop in number of Physics graduates who are training to become teachers in both Sweden and England (Physics World, 10, 99, p.4).

However, the situation in Physics in Scotland does not seem to fit this general picture. There is no shortage of trainee teachers who want to teach Physics in school in Scotland, where there are " *more applicants than available places*" (Ireson, 1998). While for the "*past dozen years or so the trend in A-level Physics entries has been downwards, there has been an increase in the take-up of Scottish 'Highers'* " (Dobson, 1998b). According to the data from educational statistics in Scotland (Scottish Examination Board, 1993-1999), Physics in Scotland is the fourth most popular subject taken at Higher Grade after English, Mathematics and Biology. The ratio (2:1) of boys to girls in Higher Grade Physics in Scotland (Scottish Examination Board, examination statistics, 1994-1997) is lower than in A-level Physics in England and Wales where it is 4:1 (Statistics of Education, School Examinations GCSE and GCE, 1991, 1994, 1995) indicating that proportionately more girls in Scotland than in the rest of the UK study Physics and, hence, have a chance to follow science-related careers where a knowledge of Physics is essential.

Because of the rather unique situation in Physics in Scotland in comparison to the rest of the UK it was interesting to investigate this "Scottish Physics phenomenon".

Although the number electing to study Physics at university level in Scotland appears to holding its own (although separate statistics for Scotland are not available), concern exists in the Physics Department of the University of Glasgow that numbers choosing Physics have not grown and there appears to be a drop in students proceeding from first year Physics course to second year Physics. [It has to be noted that, in the Scottish University degree, students in the first year Physics class may proceed to Honours in subjects other than Physics].

In previous work, attitudes have been found to be the best predictors of students' intentions to enroll in science classes (Gardner, 1975; Stead, 1985; Crowley and Coe, 1990; Koballa, 1988; Crawley and Black, 1992). In exploring the "Scottish phenomenon", it was decided that the most useful way forward was to gather information about students' attitudes towards Physics at all stages of secondary schooling as well as during the first two years of university Physics courses. The main aim was to seek to gain insights into the factors which were making Physics so popular at school at the Higher Grade (university entrance qualification) although numbers electing to take Physics at university were not growing.

Ideally, a longitudinal study would be a better tool in tracing the factors causing changes in pupils' attitudes when they move from level to level and in understanding variations that may influence pupils' attitudes towards Physics. This kind of analysis (obtained from the same pupils at intervals over a long period of time) would allow some control of the effects of many variables that can influence modifications of pupils' attitudes. A cross-age review (measurement at only one time with students of different age) does not allow this kind of differentiated analyses (Hoffman *et al*, 1985). However, cross-aged analyses allow the development of "snap-shots" of attitudes held by pupils simultaneously at various stages of schooling. Because of time limitation in conducting this research, the cross-age analysis was employed.

In focusing on attitudes, it was accepted that other factors might also be important. Although it was recognised that an exploration of all other factors might prove impossible in the time, nonetheless, an attempt was made to observe any other influences, which might seem to be important. For example, the openness of the

Scottish curriculum structure at secondary school level is well known to be very different from that operating in England where Physics is declining in popularity. While this might be a factor, it was noted that similar structures exist in many European countries and these countries seemed to be characterised by a loss of Physics popularity (for example Germany). Thus, while structures might be important, they cannot be key factors on their own.

In looking at attitudes of learners at several stages, it was hoped that insights might be gained on the key influences that were allowing positive attitudes to develop towards Physics in Scotland. The study might also pin-point negative factors which were influencing learners away from Physics.

This study seeks to explore attitudes towards Physics in general and, specifically, the learning of Physics, the potential relevance of Physics, and experiences in school and university Physics. In carrying out this work, the following more focussed aims will be addressed:

1. To obtain the cross-age picture of pupils' reactions towards school syllabus in Physics through analyses of pupils' attitudes towards Physics lessons.

2. To analyse the factors which influence pupils' intentions towards Physics and appreciate the role which attitudes towards Physics play in this process.

3. To look at students' reactions towards the University of Glasgow Physics course and investigate factors which retain students in the subject and which cause students to leave it.

4. To look at any organisational aspects of the university Physics course which might affect attitudes towards Physics.

5. To investigate, separately, girls' and boys' attitudes towards their current Science/Physics lessons in order to explain the problems relating to the "shortage" of girls in Physics. Where does the problem start? Can anything be done to attract

more girls to Physics? What are the reasons for higher popularity of Physics among Scottish girls than among girls in the rest of the country?

Chapter 1

Psychological Theory of Attitude

Attitudes have been the subject of investigation by social psychologists for decades. It can undoubtedly be considered as one of the most extensively studied psychological concepts. In 1935, Gordon Allport wrote that the concept of attitude is *"the most distinctive and indispensable in contemporary social psychology*". This phrase still makes sense today.

The interest in research related to attitudes developed from the 1920s. Since then numerous research projects, both experimental and theoretical, have been generated to investigate and explain the nature of attitudes: ways they form, are stored, are retrieved, can change, and the ways they influence behaviour. Interest in attitudes has continued unabated since then and this can be explained because of the important functions attitudes were thought to serve and because of the presumed ability of attitudes to direct and predict behaviour. The three main functions that attitudes serve can be defined as following (Reid, 1978):

1) attitudes make sense of yourself;
2) attitudes make sense of the world round us;
3) attitudes make sense of our social interactions.

In other words attitudes allow the individual to make sense of his entire world through which he appreciates the world round him and builds social interactions. That is why attitudes have an important meaning both for us and also for other people: attitudes held help other people to know what to expect from us. Knowing attitudes "*presumably helps others to predict the kind of behaviours we are likely to engage in more accurately than almost anything else we can tell them*" (Petty and Cacioppo, 1981, p. 8).

1.1. Definition of attitude

The definition of attitude has a "*long and complex history*" (Oppenheim, 1992). 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*". This definition is not particularly precise, but is still in use today, for example in science education (Germann, 1988). Allport (1935) gave the definition of attitude as a "*mental and neural state of readiness to respond, organised through experience, exerting a directive and or/dynamic influence on behaviour*". This definition, although historically important, could not distinguish attitudes from any other mental states such as mood or interest or other tendencies or dispositions of individual which can also be defined exactly in the same way.

Later on, in the definition given by Shaw and White (1968), the three main components of attitude were specified: cognitive, emotional (affective) and action-tendency (behavioural). Their definition was formulated as following: *"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 predisposing the individual to behave in a certain manner towards the object."* All the definitions above can be summarised by Oppenheim (1992) which suggests the modern interpretation for the attitude definition 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)*

Although in the definitions given by Shaw, White and Oppenheim the main features of attitudes, namely their cognitive, affective and behavioural structure were stressed, these definitions suffer from the same shortcoming as the definition given by Allport (1935). An important feature of attitude which makes it distinguishable from such mental states as mood, habit, interest is *evaluation*. 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 of attitude 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 attitude object will not have an attitude towards it until the evaluative response about this object occurs. The evaluation of an attitude object can be done on the cognitive, affective or behavioural basis or a mixture of them.

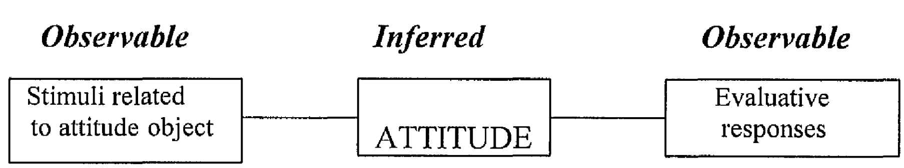
The definition of attitude given by Chaiken and Eagly (1993) and formulated above was adopted in the conducting of the present research work.

1.2 Method of an attitude investigation

One of the largest problems of attitudes investigation is in their latent construct nature: attitudes cannot be directly measured, but only constructed from observed responses taking place under certain, also observed, stimuli connected to an attitude object. In psychology they connect the kind of responses observed under certain stimuli to a certain kind of mental state (mood, interest, attitude, habit). So, attitude can be considered as one of the numerous mental states that psychologists have constructed to explain why people react in certain ways when confronted with certain stimuli.

The general picture of attitude investigation can be represented as following: (Chaiken and Eagly, 1993):

Diagram 1-1: General way of attitude investigation



Any knowledge of people's attitudes can only be constructed from observed evaluative responses. The evaluation produces a psychological tendency to respond about an attitude object with some degree of favour or disfavour that lasts for at least a short time. When a person expresses the same responses about an attitude object over and over again, it is said that the attitude has been established or formed. Being established, an attitude will be stored in the long-term memory and can be activated under the presence of an attitude object or cues related to it.

An attitude object can be everything that becomes an object of thought. It can be a concrete object/subject (e.g. school, teacher), an abstract object, (e.g. knowledge, freedom), it can be behaviour (e.g. doing experiment) and classes of behaviour (e.g. doing university Physics laboratory course). An attitude towards an attitude object will not have place until evaluation of this object occurs.

1.3 Ways of attitude formation

As has been stressed in the definition of an attitude, *evaluation* plays a key role in attitude formation. The evaluation of an attitude object can be done in three ways: on the basis of

- cognition (knowledge, thinking),
- affect (feelings, emotions, mood),
- behavioural process (consistency with prior behaviour)

or a combination of them. Thus, it can be said that an attitude can be formed through cognitive, affective or behavioural processes exclusively or through different combinations of them (Zanna and Rempe, 1980).

1.3.1 Cognitive way of attitude formation

A cognitive process takes place when people obtain any information about an attitude object and form beliefs. Beliefs can be defined as "*associations or linkages that people establish between the attitude objects and their various attributes*" (Fishbein and Ajzen, 1975). Information about an attitude object can be obtained through two processes - through a direct experience and through an indirect experience. Direct experience implies a person's direct involvement with an attitude object (e.g. if Physics lessons are considered as an attitude object then a pupil attending the classes forms beliefs about Physics lessons through his direct experience). Indirect experience implies that a person can get information about an attitude object through different sources without engaging in direct relationship with an attitude object (e.g. a pupil could obtain an information about Physics lessons from his friends or older brothers/sisters and form beliefs about the subject without any engagement in it). It was noticed that children might develop strong beliefs about science and scientists before they start formal education in school. These beliefs can be formed under the influence of different external factors, like TV programs, literature, parents and older peers, for example. Research has shown that some of these beliefs are very strong (e.g. stereotypes of scientists held by primary pupils, [Newton and Newton, 1992]). A general idea that people can form beliefs about attitude objects from indirect experience with them is particularly important in research on persuasion and its influence on attitude change.

1.3.2 Affective way of attitude formation

Affective or emotional forming of attitude can take place when an attitude object is paired with certain stimulus (positive or negative). A person evaluates an attitude object on the basis of feelings about it and it is said that an attitude is formed through an affective process. If a pupil attending Physics class finds lessons interesting and enjoyable, likes the teacher and feels great in the lessons, it is very likely that "Physics lessons" will be evaluated positively and that the pupil's attitude towards Physics lessons will be considered as positive.

1.3.3. Behavioural way of attitude formation

Behavioural forming of attitude takes place when the evaluation about an attitude object builds on the basis of past behaviour (Bem, 1972). People tend to make evaluations that are consistent with their prior behaviour. For example, a pupil who has been doing Physics thinks that it is a good idea to take the subject next year because he is good at it. In this case neither beliefs about Physics, nor emotions about it will determine his attitude towards Physics. An attitude will be formed on the base of pupil's positive past experience in the subject.

Thus, in talking about the ways attitudes can be formed, all three processes - cognitive, affective and behavioural - should be taken in to account (although it is not necessary that all of them must be present at the point of an attitude formation). Attitude towards Physics, for example, may involve all three elements (not necessary all of them have equal contribution): Physics may be perceived as an important, fascinating, challenging subject (cognitive element), the lessons are interesting, enjoyable and the teacher is great (emotional element), doing Physics classes is very satisfying experience (behavioural element).

Unfortunately little is known about the ways attitudes are stored in the long-term memory. It is valid to assume that an attitude might be a multi-dimensional complex construct rather than one-dimensional linear structure as it is sometimes supposed (Chaiken and Eagly, 1993, p.17).

1.4 Attitude analyses

Since attitudes are latent constructs and cannot be measured directly, the only way to know about attitudes of people is to observe their responses under certain stimuli regarding an attitude object. Social scientists have assumed that the responses that reveal people's attitudes can be divided in three categories as well - cognitive responses, affective responses and behavioural responses. It is unlikely that there is an exact relationship between the way an attitude has been formed and the way it has been expressed (Chaiken and Eagly, 1993).

1.4.1 Cognitive way of attitude manifestation

When people form attitudes towards an attitude object through the cognitive way, they form beliefs about the attitude object. 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 can be associated with beliefs like: a) too mathematical, b) involves problem solving, c) describes nature and its laws, d) useful subject to know.

Evaluation of beliefs associated with an attitude object can be carried out on a scale from 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 attributes, whereas people who evaluate an attitude object unfavourably are likely to associate it with negative attributes, but less likely with positive attributes. A pupil, who likes Physics will be likely to say that it is very good to develop problem-solving skills, learn how to apply mathematics, learn about nature and its laws.

1.4.2 Affective way of attitude manifestation

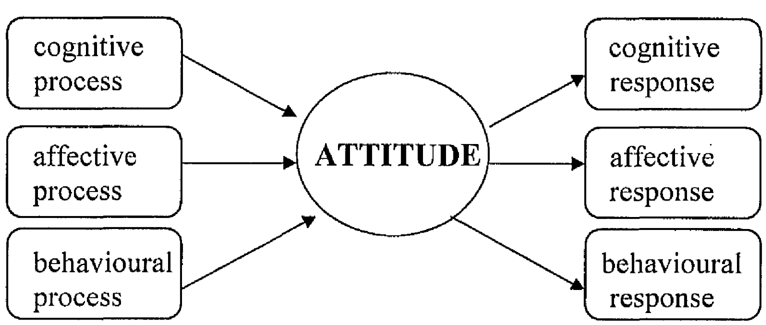
Affect is another type of responding by which people may express their evaluations. The affective category consists of feelings or emotions that people have about an attitude object. Feelings and emotions can also range from very positive to extremely negative and therefore have an evaluative meaning. In general people who "evaluate an attitude object favourably are likely to experience positive affective reactions with it and unlikely to experience negative affective reactions, whereas people who evaluate an attitude object unfavourably are likely to experience negative affective reactions with it, but unlikely to experience positive reactions" (Chaiken and Eagly, 1993, p.11). As a typical example of an affective way of attitude manifestation, the following pupil's responses about Physics classes can be considered: "I like Physics lessons because: lessons are interesting and enjoyable, the teacher is great, Physics is fun".

1.4.3 Behavioural way of attitude manifestation

The behavioural category consists of people's overt actions with respect to the attitude object. Because these responses also range from extremely positive to extremely negative, they can be located on the evaluative dimension of meaning too. Behavioural intentions can be also considered as types of behavioural responses although they are not necessary expressed in overt behaviour. By observing a pupil doing Physics in the class it may be possible to evaluate what kind of attitude towards the subject this pupil held. Very often people's overt action can be the best demonstrations of their attitudes.

The general picture about an attitude formation and its analyses can be presented as following (Chaiken and Eagly, 1993):

Diagram 1-2: The ways of attitude formation and investigation



1.5 Attitude change

In considering an attitude change, two extreme dimensions of this process can be defined:

- internal dimension where attitude is changed mostly due to motivation, desire and control of an individual;
- external dimension where attitude is changed mostly due to pressure from outside (e.g. new information) and which forces a change in attitude. This type of attitude change is not always under the control of an individual.

In real life (as well as in the education process) we are dealing with something in between these two extremes. It is impossible to keep totally out of contact with the world around us and its pressures: in reality we interact with different information, norms, rules, and so on. Some of these factors can have a very strong impact on attitude change; some no effect at all. The ways attitudes may be changed and why this happens will be discussed below. It is hoped that understanding the process of attitude change may be very important for conducting some intervention programmes in education in order to influence pupils' attitudes towards studying various subjects.

1.5.1 Internal way of attitude change

Literature has many examples and models explaining attitude change in terms of an internal dimension. Only one of them (Dissonance Model) will be discussed here, because of its possible relevance to Education.

Dissonance Models arise from the more general Balance theories. It has been proposed, that a person's attitudes consist of elements of knowledge which are called *cognitions.* The number of these cognitions is enormous. They are interconnected to each other and organised in structures that form the cognitive system of an individual. According to the Balance theories the most pleasant, desirable, stable and expected condition of a relationship between any set of cognitions to which a person attended is the harmony and balance between them (*Heider, 1958*). Thus, there is a strong tendency for people to maintain the balance and harmony between elements of his/her cognitive system.

When new information contradicts existing knowledge and disrupts the existing equilibrium among the elements of the cognitive system, a person will try to find ways to reduce the inconsistency by readjusting the system of elements so they can be again in harmony. Inconsistency is always an unpleasant state and causes a person to feel uncomfortable. One of the way to restore the internal consistency is by means of an attitude change. That is why, as an outcome in seeking to reduce inconsistency (instability), a new attitude might be formed.

Thus, in general, the Balance theories show that internal inconsistencies tend to lead to internal instability (a very uncomfortable state for a person) and this instability can be observed through overt behaviour. Attitude change can be considered as one of the outcomes of reducing this instability.

Cognitive Dissonance theory was developed on the basis of the main concepts of Balance theories. The author of the Cognitive Dissonance theory, Leon Festinger (1957), considered dissonance as a psychological state that leads to arousal. Arousal is observable. 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 oriented towards reducing or eliminating the dissonance. Successful reduction of dissonance is rewarding in the same sense that eating when one is hungry is rewarding*" (Festinger, 1957, p.70).

Festinger suggested that there are three possible ways of reducing dissonance.

- The first way suggests that a person can reduce or eliminate dissonance by changing the existing elements of knowledge to make the previous cognitive system and newly obtained knowledge consistent. This may lead to attitude change and changes in behaviour.
- The second way suggests that it is necessary to find and accept the consonant elements from the source of dissonance (an element of knowledge that does not contradict the previously held system of cognition). This will lead to reducing dissonance, but may not lead to attitude change.

- The third way of reducing cognitive dissonance can be achieved by denying the importance of new cognition. This way does not lead to attitude change but makes the previous attitude position even stronger.

However, whichever way of reducing dissonance is adopted, it is possible to say that the resulting attitude leads to greater internal mental consistency. Experiencing dissonance, feeling uncomfortable with the previously held attitude position and working towards restoring the condition of balance and stability, the person will readjust the system of cognitions and adopt the attitude which makes him feel comfortable and which he will be able to defend.

All these three ways of reducing dissonance can be considered as "internal" (cognitive) ways – restoring the state of balance between the elements of the cognitive system is a result of thoughts, ideas and arguments that a person generates himself. If this leads to attitude change, the new attitude can be considered as having greater consistency towards the previous one. If it does not lead to attitude change the held attitude can also be considered as of greater consistency towards the previous one, even though no serious changes in the previously held system of cognitions were involved. As an outcome, a person possesses more confidence to defend his attitude than it was before dissonance occurred.

The first way can be considered as the most difficult way of dissonance reduction since people normally find it difficult to change their existing beliefs, attitudes and behavioural elements.

A pupil at school can be put into a learning environment which can cause some dissonance in his system of cognitions (beliefs), [for example, a pupil was forced to take a subject which he did not like, i.e. his attitude towards the class was negative]. Soon after a pupil might find that the lessons were interesting, the teacher was enthusiastic and it was a fun to attend the class. The real atmosphere of the lessons does not match the pupil's beliefs about the classes and this may cause dissonance. Working towards restoring a state of balance a pupil may follow the ways suggested by Festinger for dissonance reduction. The first way will lead to reducing dissonance through changing attitudes towards the subject (from unfavourable to favourable) which may lead to changes in the pupil's behaviour towards this subject. It might happen that a pupil found it more beneficial to keep the previously held attitudes (e.g. to be consistent with himself). If the last one occurs it would be extremely difficult to change his attitude because the resulting attitude would be of greater consistency towards the previous one. In this case, the behaviour of this pupil in the classes may deteriorate.

1.5.2 External way of attitude change

Persuasion will be considered as a method related to the external way of attitude change. Because the methods of persuasive models can be widely used in Education, it was decided to devote some attention to this approach.

Persuasion as a normal English word has overtones that almost make it manipulative. The word is used in Psychology without these unacceptable overtones.

Persuasion and its role in attitude change has been a subject of intensive research since the early 1930s. The reason for this enormous interest towards attitude and persuasion is in the presumed ability of attitudes to predict and direct behaviour. The real pioneers of this direction of attitude-change research can be considered to be Carl Hovland and his colleagues at Yale University in the USA. This group was one of the first to investigate intensively the role of a persuasive message on attitude change. This interest has generated an enormous amount of work. Much research has been done to investigate the role of an external message on attitude change and its influence on behaviour. If a person was exposed to a certain kind of information, how would this influence his attitude? Why in some cases may attitude changes occur under the influence of a persuasive message but in some cases may not? Are changes of attitude under the influence of a persuasive message permanent or can an old attitude be restored? How do changes in attitude influence a person's behaviour?

Arising from the wealth of research in this area, many models of attitude change under the influence of persuasive messages have been constructed and adopted. Most of these models have contributed significantly to the knowledge of attitudes and the ways they can be changed.

Taken together, the existing "persuasive" models can be thought of as emphasising two distinct routes of attitude change (Petty and Cacioppo, 1981):

- the *central route*. This can be defined as a *thoughtful* consideration of the attitude object. It emphasises the information that a person has about an object or issue under consideration. Attitude change through the central route is due to active thinking about an issue provided by the message.

- the *peripheral route*. Attitude change through the peripheral route does not involve any active thinking about attributes of the issue or object under consideration. This way of an attitude change is not a very thoughtful one: it allows a person to decide what attitudinal position to adopt without engaging in any extensive cognitive work relevant to the attitude object. The attitude can be changed just under the influence of emotions or impressions for example. This way of attitude change can be considered as "intellectually cheap".

Generally speaking, the difference between the central and peripheral routes is in the extent to which the attitude change that results from the external message is due to active thinking.

Some models from the central route focus on how the arguments in a persuasive message are comprehended and learned: for example the message-learning approach developed by Hovland and his colleagues at Yale, 1953. These researchers examined how different variables affected a person's attention to, comprehension of, yielding to, and retention of the arguments in the persuasive message. According to their model, for a message to be processed it should be attended to, understood and comprehended (Hovland, *et al.*, 1957). Other central approaches focus on the information that people generate themselves in response to a persuasive message. In such a case, the attitude change that occurs under the influence of an external message is the results of thoughts, ideas and arguments that the person generates himself. The personal motivation to process the message is playing an important role in this process (Petty, Ostrom & Brock, 1981). The view of the persuasion process that emerges from these approaches appears to be a very rational one. The personal relevance, interest, motivation, benefit should be switched on to process the message. The recipient attends to the message arguments, attempts to understand them, comprehends and then evaluates them. The Dissonance model described before can be used to explain what will happen when evaluation of the persuasive message lead to cognitive dissonance and how this may lead to attitude change.

According to the models considering attitudes change through the peripheral route, attitude change can be determined by such factors as:

- *Reward and punishment*:

  Classical conditioning of attitude change or associative learning is an example of such approach. People tend to like objects and recommendations that previously have been paired with unconditioned stimuli that generate positive affective responses and to dislike objects and recommendations that previously have been paired with unconditioned stimuli that generate negative affective responses. For example, an unpleasant smell in the chemical laboratory can develop negative attitude towards Chemistry classes. Operand conditioning is another example of associative learning. It based upon the supposition that people act to maximise the positive and minimise the negative consequences of their behaviour. Another example from education is - students like the course, at least in part, due to the reward that they receive in the course: achievement can generate positive attitudes towards studied subject.

- *The attribution approach*:

  People tend to adopt the position of an expert, since it is likely to lead to the reward (pairing of expert with reward). Pupils in the class may adopt the point of view of the teacher because this may lead to positive consequences, like getting a good mark, for example.

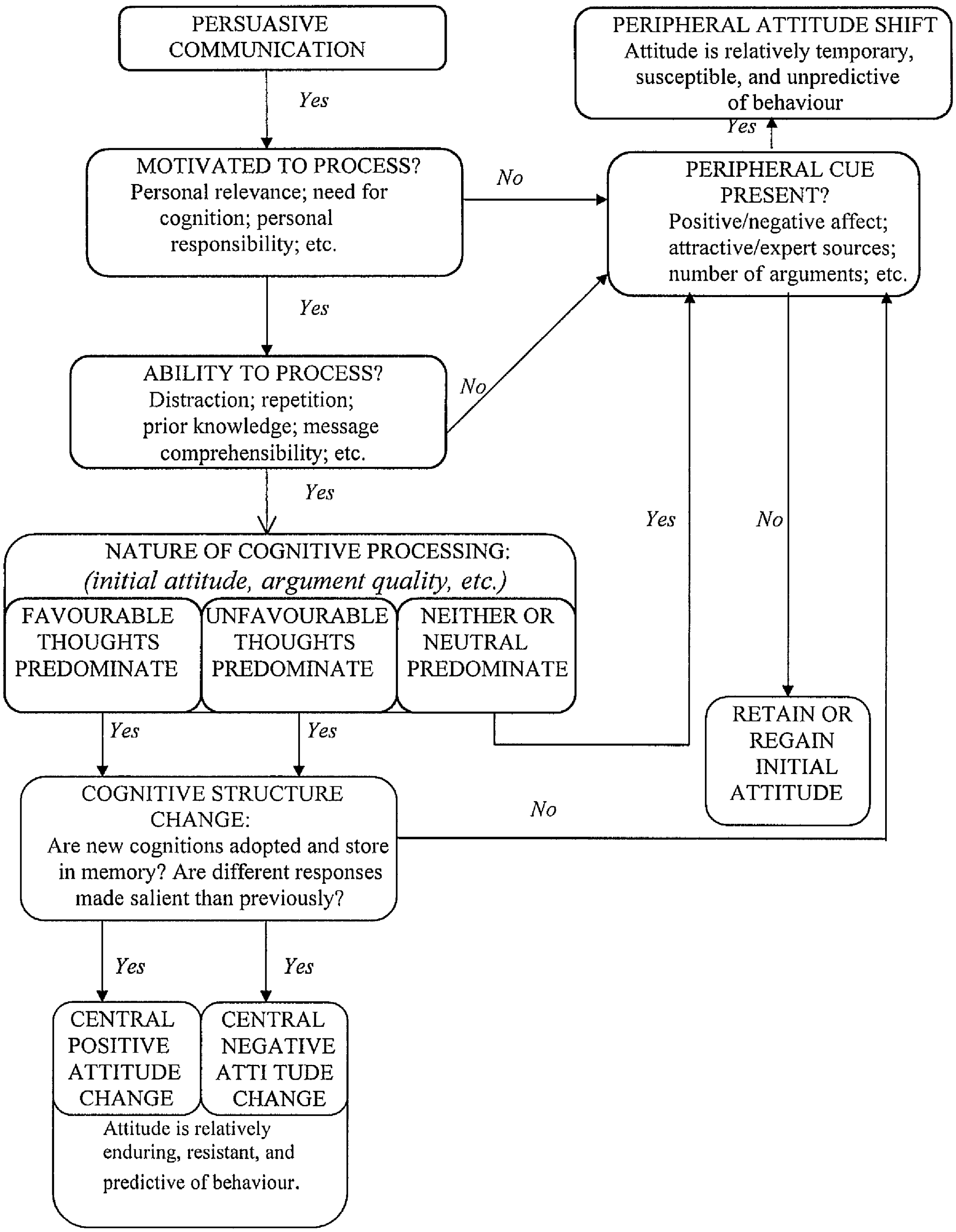
It has been observed that, when the issue of the persuasive message is personally relevant to a person, researches reported more polarised attitudes. On the other hand, when the issue to be discussed was not personally relevant, more moderate attitudes were observed (Petty and Cacioppo, 1981). When discussing a topic of low personal importance, the dominant motive of the recipient is producing a favourable impression of himself/herself. Adopting an attitude position for this reason does not require thinking about the merit of the issue. But, when discussion is on a topic of considerable personal importance, people are more concerned with defending their *true* positions than with creating favourable impressions of themselves. Preparing to defend one's position does require issue-relevant thinking. The subject who expresses polarised attitudes after being exposed to persuasive messages, therefore, follows a central route of attitude change, but the subjects who demonstrate moderate attitudes follow a peripheral route of attitude change. It was found that central route produces more permanent changes in attitude than does the peripheral route. Behaviour is easy to predict from the persuasive message proceeding through a central route.

The schematic depiction of the processes taking place through the central and peripheral roots can be seen on the Diagram 1-3 taken from the work of Petty and Cacioppo (1986, p126). The Diagram 1-3 represents the way attitude can be changed through the central or peripheral rout, the conditions and factors necessary to proceed each of the way.

Persuasion can be considered as a powerful tool of attitude change and control in Education. The summary of how to construct a science-specific persuasive message and practical advice about how to conduct a persuasive intervention in education (both at school and university level) are given in the Appendix S.

In this study the definition of attitude proposed by Chaiken and Eagly (1993) was used. This emphases on evaluation element of attitude. On the basis of this the study will seek to explore the kind of attitudes learners have towards Physics and the way these attitudes develop.

Diagram 1-3: Central and peripheral routes of attitude change.



Chapter 2

Attitude Measurements

Attitude measurement is a problem of a great importance for attitude researchers. Being defined as a latent construct, it is obvious that any knowledge about attitude can only be constructed by inference from the measured responses. In another words it can be said that *"attitudes are what attitude measuring devices actually measure"* (Reid and Johnstone, 1981) and that is why, without techniques for measuring attitudes, research in this field would be impossible.

There have been many problems about attitude measurements until now. This is exemplified by Rickwood (1984):

> *"in the fields of attitude research there exist a degree of divergence of views and opinions over the nature of attitude. The range of opinions that exist over the nature of attitude has failed to produce a clear conceptual base on which the measurement of attitude can be based."*

Cook and Selltiz *(1964*) categorised the techniques of attitude measurement into five types and their analyses has stood the test of time:

1) self report (questionnaire);
2) observation of overt behaviour;
3) partially structured stimuli (akin and projective tests);
4) performance of tasks (congenial material learned rapidly)
5) physiological tests

These five types of attitude measurements can be considered under two broad types of approaches – the *Direct* approach and the *Indirect* approach. The *Direct* approach involves direct contact with the person by means of questionnaires or interviews or both of them. With direct procedures, a person is asked to provide a self-report of his or her attitude while the *Indirect* method does not involve the subject directly in the research: his/her attitude is extracted from the set of indirect investigations (observations) when the subject does not necessary suspect that he is the subject under the investigation. There are lots of different techniques developed for both of these methods. Both of them can give a broad spectrum of information, but no one of them is perfect. As was pointed by Cook and Selltiz (1964), it is dangerous to rely in research on only one of these techniques.

The indirect method of attitude measurement can be a useful tool in measuring attitudes if for some reason there is a concern about accuracy of providing information through the direct measurements. Being unaware that an attitude is being measured, it is possible to minimise the subject's concern about "appropriate" or "desirable" responses. However, indirect procedures of attitude measurements are frequently cumbersome, often involving considerable time for researchers with the final results being open to misinterpretation. That is why direct measurements are the most common techniques used in attitude measurements.

In science education, research in the field of attitude also involves a number of different measuring techniques, mostly based on direct methods. Direct methods allow the collection of data from a large number of people over a reasonably short period of time. The mostly widely used techniques include self-report questionnaires and interviews.

2.1 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).

The questions used in a questionnaire can be 'open' or/and "closed" ones. A *closed* question is that one where the respondents are offered a range of fixed possible responses and they must select their choice. An *open* question does not contain any kind of choice, the respondent provides his own answers in his own words. Both these types of questions have their advantages and shortcomings.

The open-ended question is easy to ask and its "*chief advantage is the freedom it gives to the respondent*" (Oppenheim, 1992, p. 112). However, the open-ended question is difficult to answer and more difficult to analyse.

Closed questions are more difficult to construct but easy and quicker to answer and analyse. The main disadvantage of this type of questions is the loss of spontaneity of answers: sometimes it restricts the respondent and does not offer adequate freedom. To avoid these disadvantages researchers in attitude often include both types of these questions (open and closed one) in the questionnaires measuring attitudes.

There are a few requirements that should be taken in to account while designing a questionnaire for attitude measurement (Gardner, 1975). First of all, the attitude object must be specified and the variety of stimulus which can help to elicit evaluation about it should be defined (for example, if consider *Physics* as an attitude object, than the following stimulus might be considered: a teacher, classroom instructions, lessons, outdoor activities, scientific TV programmes, etc.). Secondly, the appropriate techniques which can reflect the evaluative character of the attitude object should be used and thirdly, special attention should be placed on the validity and reliability of the methods used for attitude measurements.

2.1.1 Reliability and Validity of Measurements

Any questionnaire designed to measure attitudes should be both *reliable* (i.e. be able to reproduce the results after a certain period of time) and *valid (*actually measure what is aimed to measure*)* (Oppenheim, 1992). Criticism of failing to note these requirements in some research studies of attitudes in education can be found in the literature reviews carried out by Gardner (1975) and by Schibeci (1984), as well as in some recent papers (Coulson, 1992; Gardner, 1996). It is very desirable to provide information about the reliability and validity of the instruments used in the modern research of attitudes in education. "*Attitude research must clearly define the construct being investigated, describe the place of this construct within a large theoretical framework of relevant variables, and demonstrate the reliability and validity of instruments used to measure it*" (Germann, 1988).

The reliability has usually been quoted with reference to the methods using summating rating scales (summating rating scales for attitude measurement consist of numerous items whose scores are summed to yield a total score which reflects the attitude). The *reliability* of a measuring method (scale) can be considered as an internal stability of the instrument, i.e. tendency of a scale to yield similar scores or values when applied to the same individuals at different times. The time interval between administration should be long enough for respondent to forget his previous responses, but short enough to prevent long-term factors to influence his attitudes. In practice the interval of a few weeks can be considered as satisfactory.

There are different methods to assess reliability, but correlation coefficients are typically used. To fulfil requirements about reliability of a scale for attitude measurement the scale should provide a set of results, which correlate with themselves on several observations. In the social sciences it is rare to find the correlation coefficients (reliability) much above 0.90.

The *validity* of a measuring instrument refers to the extent to which the instrument measures what is expected to measure, i.e. whether the data or values obtained from the measurement really indicate people's attitude toward the object. There are two useful opportunities to check validity. One of them is a random interviewing of people as they complete the questionnaire using a structural interview technique. Another one is an expert approval of the methods designed for attitude measurement. (These two approaches were used in the present study to check the validity of the data collected).

2.1.2 Methods for attitude investigation

There are several methods, which are traditionally used for attitude measurements. All of these methods reflect the evaluative character of the attitude measured and provide the opportunity for respondents to express their evaluation of an attitude object on a scale which allows them to classify the stimuli between extremely favourable and extremely unfavourable including the neutral one.

The pioneer of the formal method for attitude measurements is Thurstone. In 1928 he published a paper "Attitudes can be measured", where he demonstrated how the methods of psychophysical scaling can be extended to attitude measurement.

2.1.3.1. Thurstone method

Although Thurstone's work has a great historical significance (for the first time it was demonstrated that attitudes could be measured), it was widely criticised for being cumbersome and time consuming. To measure an attitude, Thurstone proposed the following steps:

1. The number of items about an attitude object was collected from the literature or from pilot interview. This should guarantee the validity of the scale. Usually about 100-150 statements were used.
2. A group of judges was appointed to judge the statements. The number of judges should be about 40-60.
3. The role of the judges was to put items into the categories of the scale. The scale normally contained 11 categories from extremely positive to extremely negative including neutral. The intervals between the categories should be regarded as equal.
4. After judges sorted out the statements, each statement was presumed to be placed in a single place on the scale. Irrelevant, ambiguous items were eliminated and extracted from the scale, thus making the scale reliable.
5. After being judged, the scale was administered. Respondents were only asked either to agree or disagree with each statement.

The method was very cumbersome and simpler methods such as the Likert method and Semantic-Differential methods are mostly in use today. These methods are discussed below.

2.1.3.2. Likert method

The Likert method (1932) can be considered as one of the most popular and widely used procedures for attitude measurements. The method provides similar results to the Thurstone method, but it is less laborious.

The Likert method eliminates the role of judges and allows the respondent to place himself on the evaluative scale according to the degree of his preference towards the attitude object. The evaluative scale for each statement normally consisted of five positions, running from "strongly agree" to "strongly disagree" including the neutral one. Respondents were asked to tick one of the five positions provided, thus expressing the degree of agreement or disagreement with a statement. Such a method, it was believed, would provide more precise information about respondent degree of agreement or disagreement with statement and hence give an opportunity to obtain more precise information about the attitude held.

Likert devoted particular attention towards the construction of a method, which could be as valid and reliable as the Thurstone one. Since there are no judges, the problem of the validity of the method depended on the constructor. Special care must be taken while collecting the items that all of them should be about the same attitude object.

The Likert method was designed to be used as a scale where a respondent's attitude is estimated by the value of the total score obtained (which is a sum of scores from evaluation of different items of the scale). According to Likert the attitude towards a particular object would be reflected by the total score obtained. If to rate "strongly agree" with positive statements about an attitude object as 5 points and "strongly disagree" with the positive statements about an attitude object as 1 point, then the maximum possible score obtained will reflect the extremely positive attitude and the minimum score will reflect the extremely negative attitude.

A central assumption underlying the use of this technique is that the items in the scale must reflect a common construct. If this requirement is not met, the scoring procedure produces largely meaningless, uninterpretable data (Gardner, 1996). That is why scoring, indeed, can be considered as one of the major problem of the Likert method. *"To add up the weight, the number of doors, the number of cylinders in a motor car to produce a single number would have little meaning*" (Gardner, 1975).

To avoid this problem, analysis of patterns of responses for each individual item instead of the analysis of the total score is recommended. Today researchers apply different methods of statistics to analyse the data obtained using the Likert method. For example, a method of chi-square allows comparison of the patterns of responses for each individual item between different groups and judge if these differences are significant or not.

2.1.3.3 Semantic-Differential method

The Semantic-Differential method is another example of a reliable and valid technique for attitude measurement that is very popular among attitude researchers today. This method was originally not developed for attitude measurement but has subsequently been found to be useful for this purpose. (The author of this method was Charles Osgood (1967), that is why the method is often called the Osgood method). The method was originally employed as a seven-point rating scale with bipolar word-pairs placed at the opposite ends of a scale. The respondent's task is to rate the attitude object on such a scale. One of the main advantages of this method can be explained in terms of its real evaluative character. The method enables the respondent to express the evaluation even in such a case when it can hardly be put into words. Another advantage of this method is in the high speed at which the scale can be completed (even by children) (Reid, 1978). Here is an example:

interesting ▢ ▢ ▢ ▢ ▢ ▢ boring
strong ▢ ▢ ▢ ▢ ▢ ▢ weak

The summation method (scoring) was initially applied for this method to judge attitudes. The scores could be considered, for example positive for positive adjectives and negative for negative adjectives, including zero for neutral ones, for example from +3 till -3, including zero - seven points. The final attitude was judged by considering the general score obtained. The scoring can be criticised using the same arguments as above relative to the scoring in the Likert method. Moreover, we cannot perform normal arithmetic on non-cardinal data. Frequencies of responses can be considered as preferable to summation.

The Osgood method was found to be both a reliable and valid method for attitude investigation. It has been reported by several researchers that the Semantic-Differential technique has a coefficient of reliability around 0.91 and has a high coefficient of correlation (about 0.90) to more cumbersome Thurstone techniques (Hadden, 1981). As was shown in the research of Heise (1970), bipolar four or five point scales "*yield adequate reliability for most purposes*". In his work, Heise (1970) has demonstrated that "*Osgood's method is eminently suitable in terms of type of sample, administration, easy design, high reliability and validity when compared to other methods*". This is the reason why the Semantic-Differential technique has become one of the most popular methods of attitude measurement.

2.2 Interview

The interview is another powerful method of conducting attitude measurements. This can be considered as even more powerful than questionnaires in collecting valid data. Interviews can also be used to check the validity of the data obtained from questionnaires.

There are two main types of the interviews considered:

- The *explanatory* interview - free style interview, which can be considered even as spontaneous conversation with an interviewee, but which allows the researcher to get deep data about an attitude position held.

- The *standardised* interview - which can be considered as asking the interviewee a prepared set of questions to collect the necessary data.

The purposes of these two types of interview are different. The purpose of a standardised interview is in collecting data, while the purpose of explanatory interview is rather to collect facts and opinions to help to develop working ideas and hypotheses. Ideally the explanatory interview is most useful when held before conducting further research to help to clarify the situation and to define the field of research, as well as after the data have been collected to check their validity.

During the standardised interview the same kind of data as is obtained from questionnaires, can be collected. However, interview has some advantages over questionnaires. An interview helps a respondent to avoid ambiguities and misunderstandings of questions. It allows the researcher to trace the order of answers and their emotional power.

The main disadvantage of interviews of both types is that they are time consuming. Usually questionnaires get answers from hundreds of respondents in a short period of time while interviews will take long periods of time to approach the same number of people. That is why the combination of questionnaires and interviews can be considered as ideal method for conducting research in some areas, for example, in education.

In this study questionnaires based on adaptations of the methods developed by Likert (1932) and Osgood (1967) were used. Semi-structured interviews which can be considered as a combination of explanatory and standardised interviews were used to check the validity of the data collected and to explain some problems risen in the process of the research.

Chapter 3

Attitudes and Behaviour

One of the purposes of the numerous researchers in the field of attitudes among science educators is in gaining theoretical and practical tools for understanding students' science-related behaviour and attracting more students to study science and pursue science-related careers. It was found that students' attitudes towards a science subject are necessary, but, unfortunately, not sufficient quality of information for predicting the science-related behaviour (Ajzen and Fishbein, 1980). Factors other than attitudes should be taken into account and considered together with attitudes to predict the likely behaviour of students in choosing science subjects.

Over the past 15 years, the Theory of Reasoned Action (TRA) and the Theory of Planned Behaviour (TPB) have gained increasing interest among science educators as quite successful tools for understanding and predicting students' science-related behaviour.

3.1 Theory of Reasoned Action

The Theory of Reasoned Action rests on the assumption that humans are rational, have control over their behaviour, utilise and process all available information before taking action. (Of course, this assumption is not always completely correct!). Its authors (Fishbein and Ajzen, 1975) argue that much human behaviour can be predicted and explained almost exclusively in terms of *individual beliefs* and *attitudes.*

According to the theory, the immediate determinant of a person's overt behaviour (B) is the person's intention to perform that behaviour or behavioural intentions (BI). The stronger the person's intention, the more that person is expected to try, and hence, the greater the likelihood that the behaviour will actually be performed. So, if it is known what a person's intention was regarding some object or person, this would be the single most important piece of information needed to predict the person's eventual behaviour. Often, however, behavioural intention is not known. In such a case a person's intention to behave can be predicted by knowing two things:

(1) the person's *attitude* toward the behaviour (*AB*);

(2) the person's *subjective norm (SN*).

Attitude towards behaviour refers to the person's positive or negative feelings about engaging in the behaviour. These feelings are a result of the information that a person has about the attitude object and about engaging in the behaviour regarding this object. A direct way to measure someone's attitudes is to ask a person to evaluate a certain behaviour. An alternative procedure for assessing attitudes is to measure the salient (readily available) beliefs (b_i) that a person has about the attitude object and obtain their evaluations (e_i).The integration process that describes attitude can be represented by the following equation (Petty and Cacioppo, 1981, p. 194):

$$AB = \sum_{i=1}^{N} b_i e_i \qquad (3.1)$$

where AB refers to the person's attitude towards the behaviour, b_i refers to the beliefs that the person has about the act's consequences, and e_i refers to the evaluation of these consequences, *i* refers to the specific belief number, where beliefs are numbered from 1 to N.

An example below demonstrates how the equation 3.1 works. Intentions to study Physics next year at school (behavioural intentions) may lead to the following consequences (Crawley and Black, 1992):

(1) attaining educational and/or career goal,
(2) increasing knowledge of Physics,
(3) learning useful information,
(4) helping grade point average,
(5) studying interesting topics.

To obtain the likelihood that studying Physics will lead to consequence (*i*) (i.e. to obtain the value for b_i, equation 3.1*)* a person will be asked to rate the consequence on evaluative scale, for example on a 7-point scale anchored at +3 by "likely" and at -3 by "unlikely". To obtain a value of e_i, each consequence (i) is evaluated on another 7-point scale anchored at +3 by "good" and at -3 by "bad". Multiplying obtained values

(b_i) by (e_i) and summing them for each consequences will give rise to the value of attitude towards a behaviour. Fishbein (1963) has demonstrated that the subject's attitude obtained by summing the products of (b_i) and (e_i) for each belief correlated 0.80 with a more direct Semantic-Differential measure of attitude.

Subjective norm is the second predictor of a behavioural intention (according to the Theory of Reasoned Action). It refers to the person's perception of the social pressures and norms to perform or not to perform the behaviour. Generally, people will perform behaviours that they value highly and that are popular with others and will refrain from behaviours that they do not regard favourable and that are unpopular with others. As was the case with attitude, it is possible to measure the subjective norm directly or by assessing the specific beliefs that build it. According to the Theory of Reasoned Action, the general subjective norm is based on the:

- person's *normative beliefs* $(NB)_i$ - expectations that important reference group or individuals endorse performing the behaviour, and
- person's *motivation to comply* $(MC)_i$ with each of the referent person or groups.

This information is integrated into a general equation, which represents subjective norm factor as following:

$$SN = \sum_{i}^{M} (NB)_i (MC)_i \qquad (3.2)$$

where *i* refers to the number of normative beliefs, which are numbered from 1 to M.

For example, for a pupil who wants to study Physics next year at school there are people who are important for him/her in taking this decision. These people can be, for example (Crawley and Black, 1992):

(1) parents/guardians,
(2) brothers/sisters,
(3) current Science/Physics teacher,
(4) friends,
(5) counsellor.

Subjective norm of the pupil's behaviour to study Physics can be predicted by multiplying his assessment of another evaluation about his performing the behaviour $(NB)_i$ by his motivation to comply $(MC)_i$ and summing the product obtained for each referent. Bowman and Fishbein (1978) showed in their work that a direct assessment of the subjective norm (SN) correlated 0.79 with the products of equation 3.2.

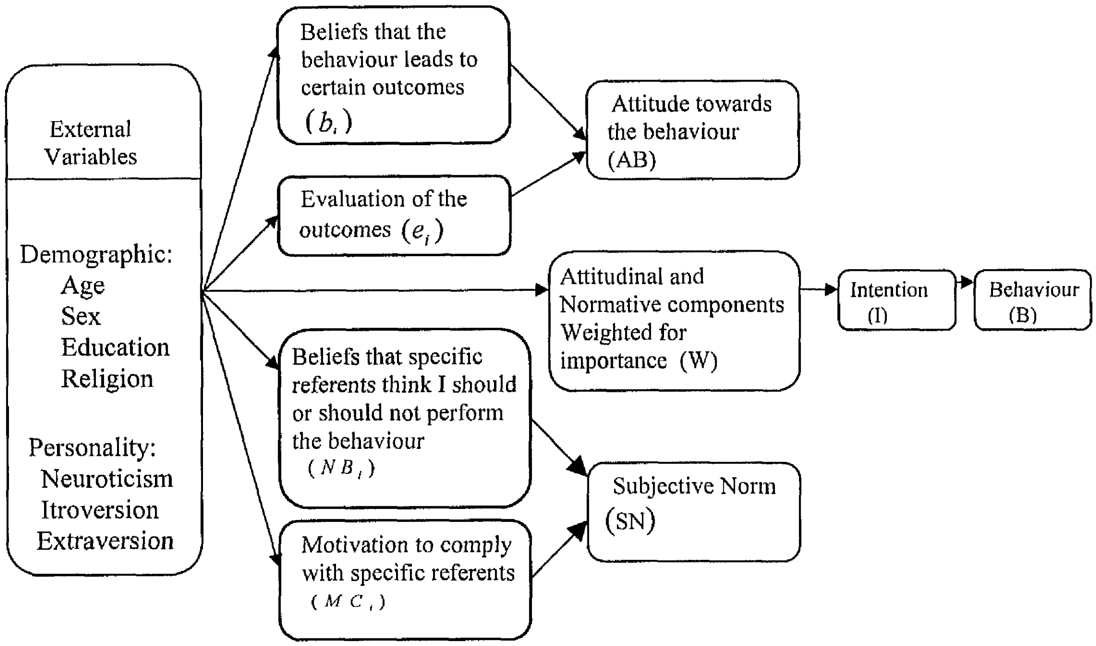
The Theory of Reasoned Action are summarised in the following equation:

$$B \approx B_i = \omega_1 AB + \omega_2 SN \qquad (3.3)$$

It should be stressed that the presentation above (equation 3.3) is not a strict mathematical formula, but rather generalisation and convenient presentation of general structure and composite parts of what is called *behaviour*, where ω_1 and ω_2 are "weights" of attitudinal (ω_1) and subjective norm (ω_2) components. These weights mean that attitude and subjective norm are not always weighted equally in prediction behavioural intentions. For some people, for example attitude can be twice as much important as subjective norm in predicting their behavioural intentions, for other people the situation can be the opposite.

According to the Theory of Reasoned Action *attitude towards the behaviour* (*AB*) and *subjective norm* component of the behaviour (*SN*) are two conceptually independent determinants of behavioural intention. A summary diagram of the theory was given by Fishbein (1980) and is represented below:

Diagram 3-1: The Theory of Reasoned Action (from Petty and Cacioppo, 1981)



The Theory of Reasoned Action has been found to be extremely successful in explaining *volitional* behaviour. Volitional behaviours are those actions that do not require skills, special abilities, opportunities and cooperation of others to perform. They require only that the individual possesses the motivation to perform the behaviour. Such kind of behaviour may be said to be *completely* under a person's control.

In Education, the Theory of Reasoned Action has been successfully used to understand and predict the enrolment patterns in Chemistry in the USA (Crawley and Koballa, 1994), girls' intentions to enrol in at least one Physical Science course in high school in the USA (Koballa, 1988), high school students' science track choice in South Korea (Myeong and Crawley, 1993), intentions of students in New Zealand to study or not to study science (Stead, 1985), intentions of middle school students to enrol in high school science (Crowley and Coe, 1990).

From the analyses of these studies it was found that the attitude and subjective norm components can be considered as sole predictors of behavioural intention, but they are differently effective for groups formed on the basis of sex, ethnicity, general ability, and science ability. In the work of Stead (1985) it was shown that the contribution of social standards and norms was of greater importance for girls than for boys in predicting pupils' intentions to study science subjects. However, attitudes were found to be the stronger predictor of the behavioural intentions for both sexes. In the work of Myeong and Crawley (1993), it was demonstrated that, in some cultures like that of South Korea, where the authority of family and parents are regarded highly, the subjective component of the behaviour alone can have a direct influence on students' behaviour in choosing science subject for further study.

3.2 Theory of Planned Behaviour

The Theory of Reasoned Action, indeed, has been criticised because of its limited applicability. Most behaviours, according to Liska (1984), are neither volitional nor involitional, but somewhere in between these two extremes. Actual behaviour may range from behaviour, which requires little skill and social cooperation to be realised to behaviour which requires considerable skill, considerable social cooperation, or both. Consider a pupil intending to study physics. This intention along with the approval of people important to him, will not necessary be enough to bring about the behaviour to study Physics. There may be other factors. For example, it may be very important that student's Grades obtained for Science/Physics course were high enough to continue studying the subject, or there should be places in the Physics class next year. The last two factors are not completely under the pupil's control.

The *Theory of Planned Behaviour* was proposed by Ajzen (1985) as an extension of the Theory of Reasoned Action to account for the performance of behaviours that are not completely under the subject's control. In fact, many factors can interfere with control over intended behaviour. These factors can be internal such as skills, abilities, and knowledge; and external, such as time, lack of resources, cooperation and behaviour of other people, opportunity. To take these factors in to account the Theory of Planned Behaviour adds a third component to the Theory of Reasoned Action, the so-called *perceived behavioural control (PBC).*

Perceived behavioural control (*PBC*) can be defined as a person's belief as to how easy or difficult performance of the behaviour is likely to be and represents the extent to which the individual believes that behavioural performance is complicated by internal (skills, ability, knowledge) and external (cooperation of others, lack of resources) factors. The more resources and opportunities individuals think they possess, and the fever obstacles they expect, the greater should be their perceived control over the behaviour.

In the same way as attitude towards the behaviour (*AB*) and subjective norm (*SN*), perceived behavioural control (*PBC*) can be evaluated directly or can be constructed from the control beliefs that combine it. The direct evaluation of a person's perceived behavioural control can be carried out by asking a person to evaluate how far he/she is able to control his engagement in the behaviour. Another way of getting someone's *PBC* is to assess the specific beliefs that are combined in it. *"People associate a limited number of controls with performance of a specific behaviour (control beliefs, cb). Then they weigh each control belief by the likelihood it will occur (likelihood of occurrence, lo) and combine each control-action association to form a generalised, self-efficacy judgement*" (Ajzen, 1988, p. 135). This construct can be represented by the following equation, which represents perceived behavioural control (*PBC*) as following:

$$PBC = \sum_{i=1}^{K} (cb)_i (lo)_i , \qquad (3.4)$$

where i refers to the specific number of the control belief $(cb)_i$, where beliefs are numbered from 1 to K.

If consider a pupil's intention to study Physics next year as a behavioural intention then the following factors may be associated with control beliefs over this behaviour (Crawley and Black, 1992):

(1) conflict with other courses,
(2) hearing that Physics is boring,
(3) dislike the Physics teacher,
(4) fear of failure.

The Theory of Planned Behaviour can be summarised in the following equation (3.5):

$$B \approx BI = \omega_1 AB + \omega_2 SN + \omega_3 PBC \qquad (3.5)$$

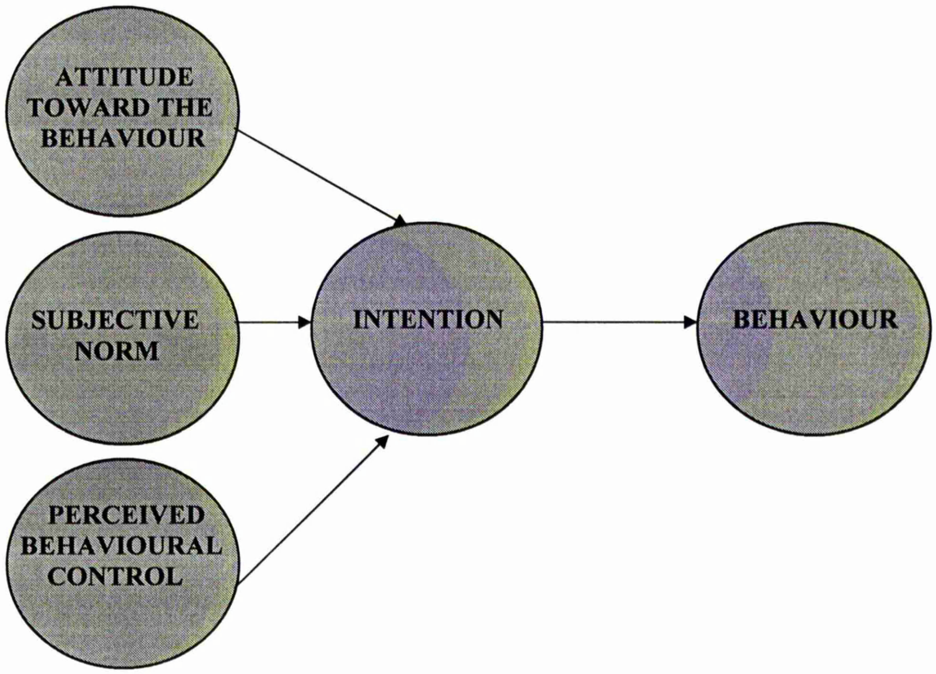
where the fist two terms of the equation are exactly the same as described in the equation (3.3): AB - attitude towards a behaviour and

SN - subjective norm component of the behaviour;

PBC - is the perceived behavioural control component of the behaviour, where ω_3 represents the "weight" of the *PBC* factor in the general picture of the behavioural intention (*BI*); (ω_1) and (ω_2) represent weight of attitude and subjective norm respectively. It means that in different situations and for different people attitudes, subjective norm and perceived behavioural control are not always weighted equally in forming behavioural intentions.

The way how the Theory of Planned Behaviour works can be summarised using the following Diagram.

Diagram 3-2: The Theory of Planned Behaviour



In Education, the Theory of Planned Behaviour has been successfully used in the prediction of secondary science students' intentions to enrol in Physics in the USA (Crawley and Black, 1992), in studying the intentions of science teachers to use investigating teaching methods in the USA (Crawley, 1990), to predict college students' attendance at class lectures and getting grade "A" in a course in the USA (Ajzen and Madden, 1985). The results of these studies have suggested that the addition of the perceived behavioural control factor to the variables of the Theory of Reasoned Action has improved the prediction of behavioural intentions. However, in general, the direct influence of perceived behaviour control alone on behavioural intention and on direct behaviour was found to be weak. It was revealed that among the three components of the Theory of Planned Behaviour, attitude had the much greater influence in the prediction of behaviour intentions than either subjective norm factor or perceived behavioural control.

These studies provide support for use of the Theory of Planned Behaviour by science educators who are interested in identifying the instrumental beliefs that students hold about enrolment in science subjects and in designing interventions to increase enrolment in these subjects. Information about the personal beliefs that determine the attitudes towards enrolling in Physics, for example, *"can be utilised to develop systematically planned interventions for the initial secondary school science courses in order to improve students' attitudes towards Physics enrolment and, at the same time, remove potential barriers to enrolment"* (Crawley and Black, 1992).

In the present work the Theory of Planned Behaviour has been employed for qualitatively (descriptive) analyses of students' intentions to study Physics for Honours at the University of Glasgow. Students' attitudes towards different aspects of their university Physics course were explored as factors underlying students' attitudes towards Physics and studying its for Honours. Perceived course difficulty, work load in the course, students' entry grades in Physics and Mathematics were considered as control beliefs of the perceived behavioural factor of the behaviour *studying Physics for Honours*.

Chapter 4

Attitude research in science education

Since the introduction of the Theory of Reasoned Action in 1975 by Ajzen and Fishbein, interest in attitudinal studies in science education has grown rapidly. This interest has generated a considerable amount of research in this area, which can be revealed through the scientific papers, and conferences devoted to attitudes in science.

> *"...about seventeen per cent of the 113 papers at the National Association for Research in Science Teaching (NARST) 1983 meetings in USA were directly related to students attitudes. About thirteen per cent of the 588 dissertations in science education listed in University Microfilms International's (1982) Catalogue were directly related to attitudes... Gardner (1983) has noted that studies of attitude have been a continuing feature of the annual conferences of the Australian Science Education Research Association... In the UK a substantial number of theses and dissertations as well as scientific papers have dealt with science-related attitudes. These informal indicators all point to the importance afforded the affective domain in science education by researchers in Australia, the UK and the U.S.A".*
>
> *(Schibeci, 1984).*

About 40 years ago the major focus of the research in education was on educational objectives in the cognitive domain. Since early 70s, the affective domain (Krathwohl, Bloom and Massia, 1964), has not only been accepted as a relevant part of the education, but also, as has been mentioned above, has become the focus of considerable research. *"It is almost universally acknowledged that educational objectives in the affective domain - those dealing with attitudes, interests and values - are of great importance*" (Choppin and Frankel, 1976).

> *"The general case for attitude research today is probably the same as it has always been: a desire to create the climate which best helps young people make sense of, and feel positive about, their experience in science lessons*"
>
> (Ramsden, 1998).

However, the research in learners' attitudes towards science has become a significantly less popular and common topic of science research today than it was in the 1980s. This may reflect the illusion that the picture is more or less known and that any new work will lead to the same conclusions as the earlier studies, namely that:

- boys are more positive towards science than girls, especially if talking about Physics, (Weinberg, 1995; Ramsden, 1998);
- interest towards science decreases with age, (Barrington and Henderiks, 1988; Simpson and Oliver, 1985; Piburn and Baker, 1993).

This position is in contradiction with the practical interest towards pupils' attitudes among teachers and education practitioners. "*Their job satisfaction is likely to be strongly influenced by their pupil's affective responses to what is on offer in class lessons, perhaps even more than by their cognitive responses*" (Ramsden, 1998).

The majority of studies devoted to attitudes towards science were carried out in schools. A large number of research reports can be considered as "small-scale" studies, often undertaken by a teacher-researcher to meet his particular needs in teaching science (Ramsden, 1998). The Universities and other Higher Education Institutions are poorly represented in the literature devoted to attitude towards science or particular science subject. However, in many Science Departments of Universities, there is a monitoring program, usually in the form of questionnaires, to obtain data about students' perceptions/attitudes towards course of lectures, quality and quantity of material suggested for learning, etc.. This information is of value for educators. However, this monitoring is another example of a small-scale study run for the local needs, often with limited understanding of how such monitoring should be organised and how to treat the data obtained. No recent examples of medium- to large-scale studies of high school students' attitudes to science have been reported in the literature.

Information about student's attitudes towards science subjects can be considered as a necessary one to predict whether or not a student will have a desire to study the subject further and even in taking it for a career (see Theory of Planned Behaviour). That is why the importance of creating the learning atmosphere which can generate pupils' positive attitudes towards learning subjects was widely recognised: "*A student's attitude towards science may well be more important than his understanding of science, since his attitude will determine how he will use his knowledge*" (Ramsay and Howe, 1969). Promoting positive attitudes has become a goal of many educators today.

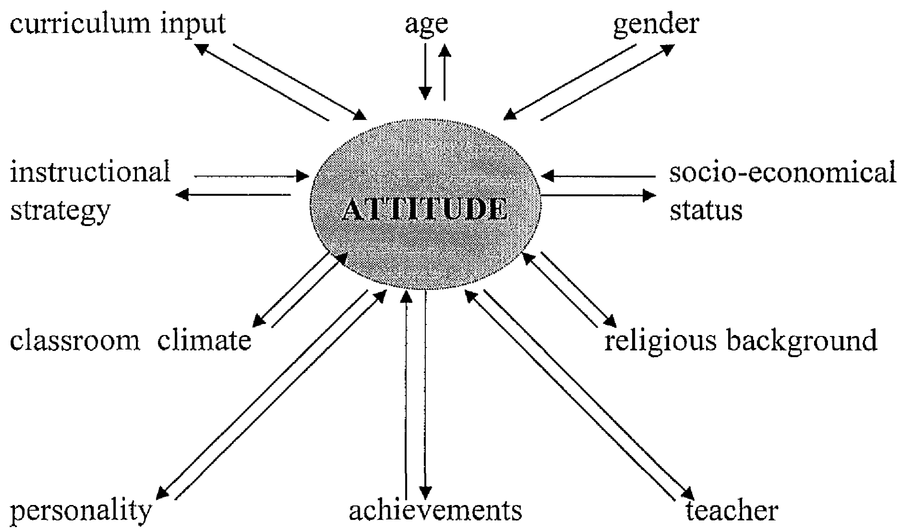
Educators investigating attitudes towards science borrowed the main concepts and methods of carrying out the attitude research from social psychology. These methods were readjusted, taking into account the learning environment where the research is taking place. The definition of the attitude towards science can be given using the words of Gardner (1975): *"person's attitude to science is a learned disposition to evaluate in certain ways objects, people, actions, situations or propositions involved in the learning of science"*

Many factors (variables) should be taken in to account in considering the possible ways attitude towards Science/Physics can be formed. These variables, which can have direct or indirect influence on attitude formation towards Science/Physics, can be a teacher and classroom environment, subject instructions, content and context of the lessons, pupils' socio-economical status and their religious background, pupils' gender and age, their achievement and personality. All these variables can be separated in two broad groups:

- *internal* (personal) variables which include:
    - personality,
    - intelligence,
    - achievement,
    - sex and
    - age;
- *external* variables, such as
    - teacher and classroom environment,
    - home background,
    - curriculum,
    - instructional variables.

There are many possible ways in which these variables can affect attitude development. Some of them may have a stronger and more direct effect on attitude towards Science/Physics, while some may be less influential, and this may vary from person to person. Attitude and its relationship with all the variables (enumerated above) can be presented by the diagram, given by Khan and Weiss (1973):

Diagram 4-1: Attitude and its variables (from Reid, 1975; originally from Khan and Weiss, 1973).



There are many difficulties in carrying out research related to attitudes. Educators investigating attitudes towards science experience the same difficulties as social psychologists. Attitudes are latent constructs and cannot be measured directly. All that researchers can do is to measure evaluative responses (related to the attitude object) taking place under specific circumstances. Since there is a "black box" called "attitude" between the way attitude is formed and the way it can be observed (see Diagram 1-1, Chapter 1), it is difficult to judge the input from the numerous stimulus (variables) affecting attitude formation.

Because of the many factors influencing an attitude and the great difficulties in measuring attitudes, much research has been devoted to investigation of the influence of a single variable, for example, such as a teacher or achievement on the attitude towards science (Gardner, 1974; Schibeci and Riley, 1983; Schibeci, 1985).

4.1 Attitude and achievement

The influence of attitude on achievement was one of the first intensively investigated topics of educators' research in attitude area. In the work of Eisenhardt (1977) with large number of students in grades six to eleven (age 11-16) in West Virginia, USA, it was found that achievement in Science, Mathematics, Social Studies and English influenced attitudes more often than attitudes influenced achievements. In the work of Schibeci and Riley (1983) the opposite conclusion was made - attitude influenced achievement more likely than the reverse. Looking at these results it is difficult to say "what may influence what". [Both processes "attitudes influence achievement" and "achievement influence attitude" could be explained using the theories from the social psychology: achievement in the subject form positive feelings about the subject and thus can be associated with positive stimulus. Positive stimulus associated with the attitude object (science subject) will likely form positive attitudes towards the subject (operand conditioning), while positive attitudes retain attention, interest and motivation to study a science subject and this may lead to a good achievement]. So, there is a big possibility of "*two-way relationship between attitude and achievement*" (Schibeci, 1984).

A number of research projects devoted to the attitude-achievement link has been conducted. In a meta-analysis of the literature devoted to this problem performed by Willson (1980), a mean correlation coefficient for attitude and achievement in science in 123 studies was 0.11 (the values ranged from -0.18 to +0.48). This can be interpreted using the words of Fraser (1982) who concluded, on the basis of these results and some others, that "*if teachers want to improve achievement, they would be well advised to concentrate on achievement "per se" instead of trying to improve achievement scores by improving attitudes*". Achievement can be improved in several ways, but at the same time "it is not necessary for the student to *enjoy* science" (Schibeci, 1984). Some educators, however, believe that students' feelings and emotions are far more important than their achievements.

In early studies, the researchers investigating students' attitude and achievement associations did not separate students according their ability. Moreover they investigated attitude towards science without separating science as Physics, Chemistry and Biology.

Barrington and Hendericks (1988) investigated the attitudes towards science of intellectually gifted (IQ>130) and intellectually average third-, seventh, and eleventh-grade (age 8-12-16) students in the USA. The conclusion they have drawn from their work says that "*intellectually gifted and average students clearly differ in their knowledge of science terms and concepts, and they similarly differ in their general attitude towards science... The gifted students found their high school science classes much more attractive than did their non-gifted peers.*"

These results were supported through another meta-analysis of the literature from 1970 to 1991 devoted to the gender differences in students' attitudes towards science performed by Weinberg (1995). In looking at the general results following from her work, the correlation between attitude towards science and achievement was found to be moderate, indicating that "*as attitude became more positive, achievement tended to increase*". The correlation was stronger, however, for low- and high- performance girls than for boys. Interesting is the difference between low- performing boys (correlation coefficient = 0.48) and low-performing girls (correlation coefficient = 0.65). Weinberg (1995) suggested that, "*for girls from the low- and high- performing groups, doing well or "achieving" in science is closely linked with "liking" science and that a positive attitude is more necessary for girls in achieving high scores than for boys*". The results of the correlation analyses between attitudes and achievement as a function of science (Physics and Biology), revealed that the correlation is slightly stronger for girls than for boys for each discipline. The relationship between attitude and achievement in Biology was found to be higher than in Physics.

On the basis of the literature review devoted to the problem of attitude-achievement associations the following can be said: there is a positive association between attitude towards the subject and achievement in this subject. The achievement-attitude associations were found to be stronger for gifted pupils and for girls. Unfortunately association does not mean causation and that is why it is difficult to say what influences what. However the associations which exist between attitude and achievement were positive. That is why the role of attitudes (students' feelings, their emotions about subject) cannot be neglected in education.

In the present work, university Physics students' entry qualifications in Physics and Mathematics and students' attitudes towards their school Physics were analysed. Factors influenced students' choice of Physics for Honours were investigated, where such factors as students' attitudes towards their school Physics and their achievement in the subject were included. University students' progress during two years of the university Physics course were monitored and correlation analyses was performed between students' entry grades and their university progress. The role of students' attitudes in their university Physics achievement will be explored in Chapter 10.

4.2 Attitude towards science and personality

Since attitudes towards a particular science subject are formed on the basis of evaluations of this subject, different internal personal characteristics such as intelligence, gender, age, personality might play a significant role in the process of an attitude formation along with other external factors. It was suggested that attitudes should be related to personality. Not everybody wants to be a doctor, actor, scientist even though they might possess ability and skills for such roles.

In some research work it was revealed that there is a relationship between students' attitudes to science and their personality. Unfortunately all the studies are varied in terms of age and sex of pupils investigated, as well as in terms of instruments used. Only a few research studies devoted to this problem will be discussed below.

From the work of Rowlands (1961), who investigated the intentions to study science subjects at the University, it was found that potential scientists are those who:

- enjoy work as much as play;
- plan to do great things;
- want as much education as possible.

Hutchings (1967) in his research with arts and science boys and girls has added some more characteristics to the image of "science pupils". He found that pupils who like doing science are:

- more realistic;
- self-reliant ;
- like logical evidence.

The later data obtained by Soh (1973) from his research with science-oriented and non-science-oriented secondary school boys from three grammar schools in England suggest that potential scientists were

- less pleasure seeking;

- more concerned with school interests;
- more concerned with family relationships.

Two studies were found where attempts were made to find distinguishing characteristics of those students who were good in studying Physical Science. In the work of Blake (1969) he compared two groups of Canadian Grade 12 students doing well and poor in Physics. He found that successful Physics students were:

- more theoretically inclined;
- less extroverted;
- more interested in social relationships;
- less conformist.

Another study was carried out by Gardner (1974) with 11 Grade Physics students in Victoria, Australia. He found that

- achievement- motivated and
- intellectual students

tended to display greater interest in Physics. Factor analyses showed that achievement and understanding themselves intercorrelate and lie on a single factor, which Gardner called Intellectual Intensity. Students high on this factor tend to enjoy Physics more. It was also found from this study that students with such a personality tended to maintain favourable attitudes to Physics only if their teachers encouraged and stimulated their achievement and intellectual activity.

The general picture, which emerges from these studies, presents potential scientists as

- relatively serious;
- achievement-oriented
- realistic
- independent,
- sociable.

In the present work, detailed analyses of students following Physics course at the university was performed. The following was considered:

- factors which influenced students' choice of Physics for Honours;
- students' expectations from the university;

- students' attitudes towards school Physics experience;
- students' attitudes towards their Physics course and their perceptions of self in the course;
- students' perceptions of being a Physicist.

Chapters 8 and 9 contain this material.

4.3 Attitude towards science and age

Only a few studies were found which were devoted to the problem of the relationship between attitude towards science and age. From the work done in this field, it appeared that the patterns of students' attitudes towards science with age are similar: *as pupils grow up their attitudes towards science decline* (Piburn and Baker, 1993; Ramsden, 1998)

Barrington and Henderiks (1988) in their research carried out in the USA found that there is a serious decline in attitudes towards science taking place between third (age 8) and seventh (age 12) grades, but there is a dramatic improvement by grade eleven (16), especially for gifted students. In the summary of Yager and Yager (1985), they wrote: "*...in many respects the students have better perceptions concerning science, science classes, the value of science, and what it is like to be a scientist in grade three[age 8] than in grade eleven [age 16]*". The 1976-1977, 1981-1982, and 1985-1986 National Assessment of Educational Progress (NAEP, USA) documented a decline in attitudes towards science from earlier to later grades.

Simpson and Oliver (1985) reported that attitude towards science declines sharply from the beginning of the year to the middle of the year and more gradually from the middle to the end. In addition to this, attitudes decline steadily from grade six (age 11) through to grade 10 (age 15).

Generally, it has been supported through many studies that attitudes towards science decrease over the years of secondary schooling and more negative views are associated with the Physical Sciences than with Biological Sciences (Ramsden, 1998). This is particularly true for girls. The American Association of University Women (*AAUW,* *1991*) reported that, as girls grow up, they lose confidence in their abilities to do science and lower their career aspirations.

Piburn and Baker (1993) suggested explanations for this decline based on their analyses of the interviews with school children from elementary, junior and high schools, which aimed *"to assess trends or changes in attitude and identify factors affecting attitude*". The results that emerged from their research showed that the origins of the decline in attitudes towards science are in the nature of "*classroom instructions and the relationships among people in classrooms*". Children began school liking science and many of the science activities they engaged in at this stage are mostly action-oriented and open-ended. Later on in the junior school, children became increasingly uncomfortable with open-ended activities: they need instructions, assessment and feedback about their work. In the upper school level students develop a *"strong work ethic and seemed to appreciate schoolwork, including tests, which they believed helped them to learn*". However, progressing from year to year the abstraction and complexity of science lessons are growing, especially in high school. This was found to have a clear negative influence on attitude towards science. But, the major reason influencing decline of attitudes towards science through grades, as Piburn and Baker (1993) suggest, is in the "*isolation of students as they moved through the grades. As the number of opportunities for student-student and student-teacher interactions, both academic and social, declined, negative attitudes towards science increased*". It is an interesting question to consider (relative to the last conclusion of Piburn and Baker, 1993): is this conclusion relevant to other subjects? In transition from primary school to secondary school, an erosion of initially highly polarised and favourable views of school subjects was observed, and the erosion was found to be more pronounced in science than it was for mathematics and geography (Hadden and Johnstone, 1983).

In the present work, the cross-aged (measurement at one time with students of different age) review of attitudes towards Science/Physics has been performed for students from upper primary through secondary school and up to university Physics students (from P6/P7 level to level 2 university). Primary school pupils' as well as early secondary school pupils' attitudes towards Science lessons were investigated, and attitudes towards Physics lessons were considered for older children and students. Patterns of attitudes with age relationship obtained in the present work were clearly different from those reported in the above studies. The results obtained may reflect pupils' reaction to classroom instructions and context of Science/Physics lessons as well as on the generally accepted stereotypes about Physics as a masculine field of activity. The results and discussion are presented in the Chapters 6 and 9.

4.4 Gender and attitude towards science

Gardner (1975) began his review of the influence of gender on attitudes towards science with the following words: "*Sex is probably the single most important variable related to pupils attitudes to science*". This is a remarkable statement, but there is considerable evidence to support it.

Harding and Parker (1995) found in their research that: "*everywhere, women are poorly represented in areas of employment that require science-related qualification, except medicine.*" For example, in Physics courses and examinations at school in England and Wales girls are under-represented by factors of approximately "*1:5 at GSE level, 1:3 at O level and 1:4 at A level. This under representation of girls in Physics is then propagated into Physics undergraduate courses (1:8), postgraduate courses (1:10) and professional activity as a physicist (1:20)*", (The Royal Society and The Institute of Physics, 1982). In Scotland the situation looks more optimistic, but boys still outnumber girls by two to one at Standard Grade and Higher Grade Physics (Scottish Examination Board, Examination statistics, 1994-98).

Despite the widespread concern about take-up of Physics courses by girls and initiatives to promote positive action, such as the WISE (Women into Science and Engineering) project, the situation still remains practically the same as it was almost 20 years ago. A report of Science and Mathematics in state schools in England and Wales (*OFSTED, 1994*) indicated that *"by 1993 only marginal improvement could be seen. The proportion of A-level Physics passes achieved by girls was still only 21 per cent*". So, the "*sex-gap in take-up of physical sciences remains as wide as before*" (Cheng, Payne and Witherspoon, 1995).

The general conclusion from the numerous research projects devoted to the gender issue and attitude towards science can be formulated as following: *boys show more* *positive attitudes towards science than girls.* This is particularly true for Physics and the whole problem for girls in science can be really considered as a problem of girls in Physics. But is it really a problem of girls?

Gender differences in attitudes towards science arise relatively early in life (Hutt, 1970). Early childhood experience, such as the environment at home or in the local community, and exposure to the media and advertising, play a vital role in shaping a child's interest and self-image (Murphy, 1990). This early socialisation, which Kelly (1981) calls "the cultural theory", may lead girls away from science "*by virtue of the toys they are given to play with, the hobbies they are encouraged in, the household jobs they are asked to help with and the masculine image of science and scientists in books, films and television.*"

The clear difference between attitudes of girls and boys towards science is also exhibited during the early primary school. This is supported by Hodson and Freeman (1983) from their observation of primary school science courses, where the structure of the courses are rather "*male-oriented with boats, cars, parachutes ... much in evidence*".

Among upper primary and secondary school children, there are numerous studies confirming that boys have greater interest in science than girls have. The nature of boys' and girls' interests in science also tend to differ, with boys relatively more interested in Physical Science and girls more interested in Biological and Social Science topics (Clarke, 1972; McGuffin, 1973). This can be explained by taking into account the personality differences and social concepts of girls and boys: girls are more person oriented, socially responsible, friendly and cooperative, while boys are tended to be more independent, achievement-oriented and dominant (Smithers and Hill, 1987). Therefore girls react more favourably to teaching which includes concrete examples related to human activity and experience and would benefit from a more context approach to science teaching and learning (Qualter, 1993). Unfortunately, Physics has traditionally been taught in an abstract rule-dominated way, which appeals more to boys than to girls. "*In general the content and context of physics activities are overtly "masculine*" (Murphy, 1990). By contrast "*biology ..., with its concern for living things,* *appears more personal and alive, and closer to the every day world and values of emotion, which women are expected to inhabit.*" (Saraga and Griffiths, 1982).

The social concepts of boys and girls lead to the result that girls' attitudes towards Physics are more negative in coeducational schools than in single-sex schools (Gillibrand, Robinson, Brawn and Osborne, 1999), while, for boys, no such relationship was found (Royal Society and Institute of Physics, 1982). In coeducational schools, girls regarded Physics as "more masculine" than girls from non-coeducational schools. It was suggested that girls will develop more positive attitudes towards Physics if they are taught separately from boys, because interaction with boys *"may actually increase rather than decrease stereotyping"* (Vockell and Lobonc, 1981). The attitudes of teachers towards girls' abilities in Physics are also very important. Harding (1982) concluded from the evidence obtained in his study that the individual behaviour and teaching style of a teacher may be more effective in influencing girls in their enjoyment and choice of Physical Science than their sex as such.

In the later high school years when science becomes optional, the difference in attitudes between boys and girls is less marked (Gardner, 1974). Interesting results were obtained in the work of Stewart (1998, England). She found out that 40 per cent of girls taking GCSE Physics rated it as their favourite as opposed to only 21 per cent of the boys. This shows that girls who choose to study Physics have made their choice more dependent on their interests and abilities in the subject than boys in choosing the so-called "masculine" subject. Similar results were reported by Matyas (1984) and Barrington and Hendericks (1988, USA) : *" in higher grades, if gender differences exist at all, the pattern appears to be for females to show increasing interest in science when compared to males of equal ability".*

In some studies, the attempt was made to explain the sex differences in attitudes towards science in terms of genetics (Hutt, 1972). Child and Smithers (1971) showed that Physical scientists scored higher on tests of spatial ability than did arts, social science or biological science specialists. In the work of Gray (1981) they have shown that males outperform females in such tasks. Taken together these findings appear to imply that females are at a biological disadvantage to males in the study of Physical

Science. This biological difference and early socialisation may lead male and female to develop a gender identity.

The role of a biological factor in explaining the difference between boys' and girls' attitudes towards science and particularly Physics can be argued on the evidences that, having once entered Physics courses, girls perform on average better than boys. When the English GCSE results of the sample of A-level Physics students were compared, the girls were seen to have overperformed the boys greatly. The differences were statistically significant. It is possible to say that females who choose to take A-level Physics are of higher ability than the corresponding males (*Stewart, 1998*). In the research study conducted by MacNab (1988) it was demonstrated as well, that spatial ability is very much needed for Biology too, where girls usually outnumber boys (Johnstone and MacNab, 1990; Johnstone, MacNab and Hansell, 1991).

Gardner (1974) pointed out that girls who enrol for Physics represent an extreme sample with respect to the attitudes of the female population. Results of testing girls taking A- level Physics have shown these girls *"more intelligent, to have a distinctive temperament, and to be less person-oriented as compared with the other girls. They were more likely to be convergent thinkers* (Child and Smithers, 1973*) four out of five girls following these patterns as compared with other subjects taken by girls where the divergent thinkers* (Child and Smithers, 1973) *outnumber convergent thinkers by five to one*" (Smithers and Collings, 1981). O'Brien and Porter (1994) make the interesting and relevant note in their work that " *the so-called problem of girls and physics is more a problem for physicists and physics educationists than it is for girls".*

The differences in attitudes towards science between boys and girls are entirely consistent with enrolment patterns in the subject, and the often substantial differences between sexes suggest that attitudes are far more important than cognitive factors in accounting for subject choice (Gardner, 1974).

The vast majority of works devoted to the problem of the gender issue in science and Physics particularly were carried out in schools. At the university level, girls were shown to be "down to earth" (Laine, 1999) in their aspiration when comparing to boys. In the present work the "gender issue" in Physics is discussed. The data about pupils'/students' attitudes towards Physics lessons were analysed separately for girls and boys (Chapter 6). Boys' and girls' interests in Physics topics and their preferred activities in Physics lessons were analysed and compared (Chapter 7). Comparing female and male student attitudes towards the university Physics course, students' perceptions of self in Physics course, students' progress in the course, factors which influenced their choice to take Physics for Honours and perceptions of Physicist are reported in the Chapters 8 and 9.

4.5 Attitudes and classroom climate/teacher

"*The educational process is a social one in which the learners and the teacher come together in an effort to share meaning concerning the concepts and skills of the curriculum*" (Germann, 1988). Several studies have looked at the relationships between the teacher variables and pupils' attitudes to science. The manner in which the subject is taught, in which the curriculum is presented, and in which the classroom activities are conducted is the result of the knowledge, world-views, beliefs, life goals, life style, needs, skills, and attitudes that the teacher brings to the classroom. Thus, personality of the teacher, his/her competence in the subject, methods used in the classroom, ability to motivate and encourage pupils' will influence pupils' attitude towards the subject.

The work of Gardner (1974) with Physics students in Australia supports the important role of the personal characteristics of Physics teachers on attitudes towards Physics. He found that intellectually stimulating teachers, those who are motivated, intelligent, achievement-oriented and enthusiastic were associated with more favourable attitudes to Physics, particularly by students who were themselves intellectual and achievement-oriented. The role of classroom environment and teacher in formation of attitudes towards science was investigated in the work of Germann (1988). He found that students of the teacher with "*better instructional methods and better learning environment had significantly better attitudes than those of the poorer teacher. When the teachers were of comparable experience, there was found to be no significant difference in students' attitude towards science*". This work supports the results of Haladyna and Shaughnessy (1982) that the teacher and the classroom environment play important roles in affecting pupils' attitudes.

Only a teacher with a positive attitude towards his subject can create a good learning atmosphere in the lessons, be enthusiastic, motivated, stimulating and encouraging for pupils. Devin and Williams (1992) have reported about the vital influence on many of today's leading scientist of their school science teachers. It was confirmed that a lack of teachers' interest is one of the barriers to effective science teaching. Some studies were devoted to investigating this problem to find practical solutions (Shrigley, 1976; Coulson, 1992). However, it should be obvious that, together with preparing high quality teachers, promoting positive attitudes towards science should also be of the goals of teacher-training courses. "Quality" of the teacher (which is not a single variable!) is judged as the most important teacher variable by pupils.

Associations exist between the Physics teacher and students' attitudes towards Physics and their perceptions of self in Physics were examined separately for female and male students. It was found that females' attitudes (those who were studying Physics at university) towards their school Physics teacher were significantly more positive than that of males. Physics teacher was strongly associated with students' attitudes towards school experience in Physics and the associations were stronger for female students. This analysis is given in the Chapter 9.

Chapter 5

Methodology of the research

This Chapter outlines how the research was carried out. It discusses the methods and techniques that were employed to gather and analyse the data.

5.1. Field of the research

The present research was conducted in the two fields – university and school.

I. ***University***:

(a) Analyses of students' attitudes towards various aspects of their university Physics course were performed:

- attitudes towards Physics course in general;
- attitudes towards course of lectures;
- attitudes towards course of laboratories and practical work;
- attitudes towards organisation of the course;
- self-evaluation of the personal progress and growth;

(b) Students' "entry information" and "course information" were analysed:

- students entry grades in Physics and Mathematics;
- students progress in the course;
- subjects studied at the level 1.

II. ***School*** (primary and secondary):

(a) Pupil's attitudes towards various aspects of their Science/Physics lessons were analysed:

- attitudes towards Physics lessons;
- attitudes towards practical work;
- attitudes towards the teacher;
- pupils' perceptions of self in Science/Physics lessons.

Apart from the questions aimed of gathering information of an evaluative nature (about attitudes), questionnaires (both for school pupils and university students) contained closed and open-ended questions which aimed to find out:

- students'/pupils' regions of interest in Physics/Science;
- preferred activities in Physics/Science lessons;
- reasons for studying/ not studying Physics;
- pupils' career aspirations;
- perceptions of being a Physicists.

5.2. Students' sample involved in the research

The total population of students involved in the present research consisted of

- level 1 and level 2 university Physics students;
- secondary school pupils from different levels, starting from S2 (age 13) till S5/S6 (age 16/17) level;
- primary school pupils from upper P6/P7 (age 11/12) year group.

Table 5.1. shows the sample of the university students participating in the research according to their level and academic year of study.

Table 5-1: Number of students participating in the research

	97/98	**98/99**	**Total**
Level 1	165 82%	67 42%	232
Level 2	53 84%	57 60%	110

Note: percentages in the Table 5-1 are of the total year group.

The Table 5.2 below shows the distribution of school pupils participating in the research according to the school and year of study.

Table 5-2: Number of school pupils participating in the research study

		Number of pupils from year of study					
	Selected schools	P6/P7	*S2*	*S3*	*S4*	*S5/S6*	*Total*
1	School 1		131	18			149
2	School 2		162	44			206
3	School 3**		90	41	74	32	237
4	School 4				63	56	119
5	School 5				15	8	23
6	School 6	142					142
	Total	142	383	103	152	96	876

Note: The data from School 3 for S4 group were collected over two-year period.

5.3. Methods of collecting the data

In order to find the reasons for some students leaving Physics after a year of their university Physics course, it was decided to build a detailed picture of students taking Physics courses at the university. Analysis of students' records was performed and the following information was analysed:

- students' entry qualifications in Physics and Mathematics;
- students' proposed degree subject(s);
- schools students came from;
- courses taken during the first year of the university;
- students progress in the course

The records of the level 1 students have been analysed. The Table 5-3 below provides information about the amount of data analysed.

Table 5-3: Number of students' records analysed

Academic year	Number of records
96/97	161
97/98	202
98/99	147

Initially, the field of the research was proposed to be only the university Physics course (level 1 and level 2). However, during the first year of the research the decision was taken to make the field of activity wider and to extend it from the university to school area. This decision was justified by the evidence that suggested that the roots of problems some first year Physics students' experience in their university Physics course might go back to school. The information collected allowed a general cross-aged picture of students'/pupils' attitudes towards Physics for each particular age (from upper primary P6/P7 up to level 2 university Physics) to be built. Students'/pupils' opinions about the profession of Physicist and being a Physicist, regions of interest in Science/Physics and preferable activities in Physics/Science lessons have been investigated as well.

Particular attention in this research has been devoted to the so-called "problem of girls in Physics". That is why almost all data obtained were analysed separately for boys and girls.

Two direct methods were employed for gathering information in the present research. They are:

1. Self-report questionnaires
2. Semi-structured interviews.

5.3.1 Questionnaires

Two sets of the questionnaires were prepared and applied during the 97/98 academic year, the first year of the present research. The first set was applied to the level 1 and level 2 university Physics students in February, 98, shortly after the beginning of the second university term. The second set of the questionnaires was applied to school pupils from S2, S3, S4 and S5/S6 years at the end of May-beginning June, close to the end of the school academic year. Only data from S2, S3 and S4 pupils were obtained. Unfortunately, it was impossible to approach pupils from S5/S6 level, since they were engaged in preparing for exams. This age group (S5/S6) was approached during the second year of the research 1998/99. Because the sample obtained from S4 pupils during the fist year of research was small (see Table 5-2) collection of the data from S4 pupils was repeated during the next year of study (1998/99).

The number of students and pupils involved in the first year of the research (1997/98) can be obtained from the Tables 5-1 and 5-2 above. The response rate obtained from the university students was high - 82 per cent of the 97/98 level 1 Physics students and 84 per cent of the 97/98 level 2 Physics students answered the questionnaires. The response rate obtained from S2 and S3 pupils was satisfactory, however the sample obtained from S4 pupils was not enough. All together data from 383 S2 pupils, 103 S3 pupils and 40 S4 pupils have been obtained by the end of 1997/98 academic year.

The questionnaires applied in the first year of the research were identical for level 1 and level 2 students [see Appendix A, University level 1/level 2 (1997/98)]. The questionnaires for school pupils were designed on the basis of the 1997/98 questionnaires for university students (to keep consistency and to allow the cross-age analyses). However, some changes, mostly simplifications, were made in the questionnaires for school pupils, taking into account their language skills and ability to handle the amount of information. In the questionnaires for S2 pupils some readjustments were done to take into account the pupils' general knowledge of science. Examples of the questionnaires for S2, S3, S4 pupils can be found in the Appendix A, questionnaires Secondary S2, Secondary S3, Secondary S4 (1997/98).

In the second year of the research study, another set of the questionnaires was applied to university students from the 1998/99 level 1 and 1998/99 level 2 courses in March, 1999 [example of the questionnaire is in the Appendix A, University level 1/level 2 (1998/99)]. School pupils from S4, S5 and S6 levels were approached in the early May, 1999 [see Appendix A, questionnaire Secondary S4 (1998/99), Secondary S5/S6]. Close to the end of the academic year (late June), primary school pupils were surveyed as well [see Appendix A, questionnaire Primary P6/P7].

The response rate obtained from the 1998/99 level 1 students was rather low (42 per cent), and 60 per cent of the 1998/99 level 2 students have participated in the research (see Table 5-1). In the second year of the research (1998/99) the questionnaires for the level 1 students were distributed and collected during laboratory time, where students could answer questionnaires when they felt it would be an appropriate time for them and they returned the completed questionnaires at the end of the laboratory. This flexibility gave rise to the rather low level of responses obtained from the 1998/99 level 1 students, when compared to the response rate of the 1997/98 level 1 students in the first year of the research, when students answered questionnaires at the end of a lecture hour, and returned completed questionnaires immediately. The total number of responses from S5/S6 pupils from three secondary schools was 96, 112 responses were obtained from S4 pupils and 142 pupils from primary school took part in the research (see Table 5-2).

5.3.1.1. Methods of attitude measurement

In order to measure students'/pupils' attitudes towards Physics, the Osgood method and the Likert method were both employed. Both of these methods are among the most commonly used techniques for attitude investigation and have been widely used in education research. Both of them provide the opportunity for the respondent to express opinions about an attitude object, by classifying the stimuli between extremely favourable and extremely unfavourable.

A six point Osgood scale was used in this research, where the respondent was asked to rate the attitude object (Physics lessons, for example) between two strictly bipolar meanings (like, interesting/boring, easy/difficult, for example). The responses obtained from such a scale were grouped into three categories: positive, neutral and negative. In the next step, frequency analyses (using a chi-square to judge the differences in responses of different group of students, like males and females, different age groups) was performed.

The Likert method was employed in the questionnaires for university students only to investigate students' attitudes towards organisational aspects of the university Physics course. The scale used was a four point one, including strongly positive, positive, negative and strictly negative options. It was decided to drop the neutral option in the scale and thus, to force students into more critical thinking and evaluation. [It was shown that an attitude object which has a personal relevance produces more polarised evaluations, while personally unrelated object produces rather neutral evaluations (Petty and Cacioppo, 1981, p.267)]. Since organisation of the Physics course has a personal relevance to students, it was possible to get valid information by using a scale without a neutral option.

Apart from the questions aimed at gaining an information of an evaluative character, the questions aimed to obtain the general information about factors influencing students' choice of the particular university; factors determining students' choice of the degree subject(s); reasons for doing various subjects during the first years of the university course; students' expectations from the university Physics course, etc.. were included in the questionnaire. These questions were presented as the closed ones, where students were provided with several options from which they could choose as many options as they felt would be appropriate. In most of the closed-questions an open-ended option was included to give students as much freedom as possible to express themselves.

5.3.1.2.Reliability and validity of the measurements

Reliability has usually been quoted with reference to the Osgood and the Likert methods being used as attitude scales. Nonetheless, reliability for these methods is well accepted (Heise, 1970; Hadden, 1981) and was not checked further in this study.

Validity for the questionnaires used in this study was checked in the following way:

- approval of the statements and methods employed for attitude investigation by someone experienced in the field of attitude research;
- approval by the Head of the level 1 and Head of level 2 Physics courses of statements and methods used;
- the correlation analyses of some data with known external criteria (e.g. patterns of enrolment in Physics, ratio of males to females in Physics classes in Scotland and England known from Educational statistics) and internal criteria (e.g. expected differences in attitudes of students planning a degree in Physics and students doing Physics as a supportive subject);
- interviews with university students conducted after the data were collected and analysed. Through the interview it was confirmed that the obtained picture of students' attitudes (from questionnaires) matched in general that held by interviewed student.

While working with primary school children, a pilot study prior to the distribution of the questionnaires was performed. Its aim was to find out if pupils had any difficulties in answering the questions and if they understood the questions as intended. Minor changes were made in the original P6/P7 questionnaire taking into account the results of the pilot study.

5.3.1.3 Statistical treatment of the data

The traditionally used methods of scoring the data obtained from the Likert and the Osgood scales have been widely criticised (Gardner, 1975; Gardner, 1996). The method of scoring the data for final analysis has serious shortcomings, especially while using scales where different variables are measured. (Discussion about shortcomings of the scoring methods was done in the literature review, devoted to the problems of attitude measurements, see Chapter 2, pp.25-26).

In the present work, the distributions of frequencies of responses were analysed for each particular statement in a question. Chi-square (χ^2) 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 is normally 5%-1%.

Correlation methods used in this research were:

- Spearman rank-order correlation coefficient (Spearman's *rho*),
- Kendall's tau-b.

Spearman's *rho* method is good enough while working with *graded scales* (scale for attitude measurement is an example of such a scale). The traditionally used method of Pearson product-moment correlation is inappropriate for carrying out the correlation analyses of the data obtained from evaluative scales, since this method has some serious restrictions:

- scores analysed must be in the form of precise numbers (like minutes, grams, etc.);
- scattergram of the data must give an unambiguous linear pattern;
- the distribution of data must have a normal distribution.

These demands are difficult to fulfil while working with graded scales. Spearman's *rho* method is more flexible and allows data to have some degree of nonlinearity while plotted on the scattergram, as well as not requiring normal distribution of data. That is why social scientists, who often work with variables which are expressed in ranks or grades along a continuum find it more appropriate to use Spearman's rho "*which is not only the correlation coefficient most appropriate for their data, but that is also gives a perfectly satisfactory degree of association*" (Clegg, 1997).

Kendall's tau-b statistic is an alternative to Spearman rank order correlation method (however conceptually and mathematically Kendall's tau-b is more complicated, but that is not important while using standard statistical packages, like SPSS for example). This method can also be employed for the analysis of data obtained from graded scales and provide results very close to results obtained by Spearman *rho*. However, Kendall's tau has advantages over Sperman's *rho:* it is difficult to obtain an accurate value for a Spearman correlation when there are tied ranks.Thus, when tied ranks are present in the set of data, Kendall's statistic is safer to use. When there are no ties Spearman and Kendall statistics give rise to similar results (Gray and Kinnear, 1998). The data obtained from evaluative scales (like Osgood and Likert scales) inevitably contain tied ranks and that is why it is recommended to use Kendall's statistic to perform a correlation analyses between any set of such data.

5.3.2. Semi-structured Interview

The interviews took place at the end of the second year of the research. The total number of students interviewed was eleven: eight students were from the 1998/99 level 1 (three females and five males) and three students were from the level 2 1998/99 Physics course. Those students who came to the interview were volunteers: in the 98/99 questionnaire there was an invitation to participate in further Interview "*we would like to interview a group of students about your view of Physics course next term. If you are willing to help, please leave your name*" [see Appendix A, questionnaire University level 1/ level 2 (1998/99)]. Eleven students from the level 1 and four students from the level 2 had left their names.

Three students from the level 1 were interviewed simultaneously in a group, while the rest of the students were interviewed individually. The time for each interview was about 1 hour. All interviews were tape-recorded.

The structure of the Interview was the following:

1. Validity of the data collected from the previous questionnaires was checked. Students were asked to give their opinions about:

a) university course of lectures (lectures boring/interesting);
b) organisation of the course (very good, good, bad, very bad);
c) tutorials (tutorials helpful/tutorials waste of time);
d) tutors/demonstrators (tutors/demonstrators helpful/unhelpful);
e) assessment methods used (very good, good, bad, very bad);
f) laboratories (interesting/boring);
g) expectations from the Physics Department (fulfilled/not fulfilled);
h) most exciting/ most disappointed experience in the Physics course.

2. Because analyses of the data showed that laboratory practice was not evaluated positively by some students, the second part of the interview was devoted to the investigation of students' views of their laboratory practice.

3. The third part of the interview was devoted to the discussion of the idea of introducing the ***Pre-*** and ***Post***-labs in the laboratory practice, the practical way of conducting it; its advantages and shortcomings.

Full report of the interview is given in the Appendix R.

Chapter 6

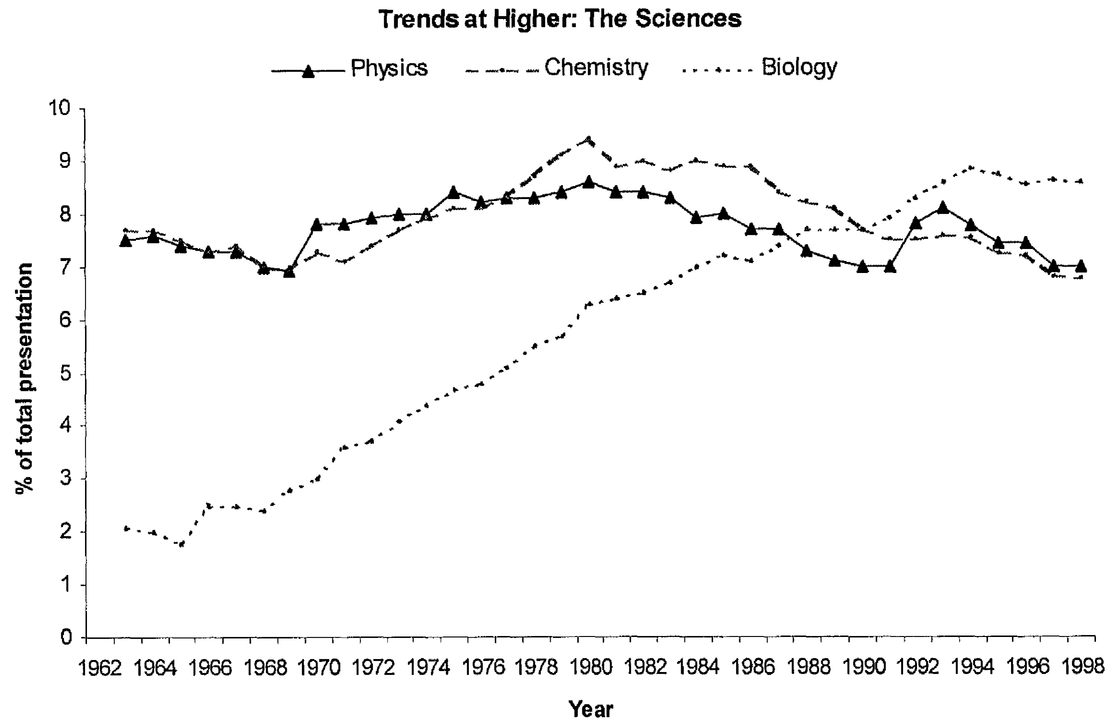
Pupils' attitudes towards Physics/Science

6.1 Introduction

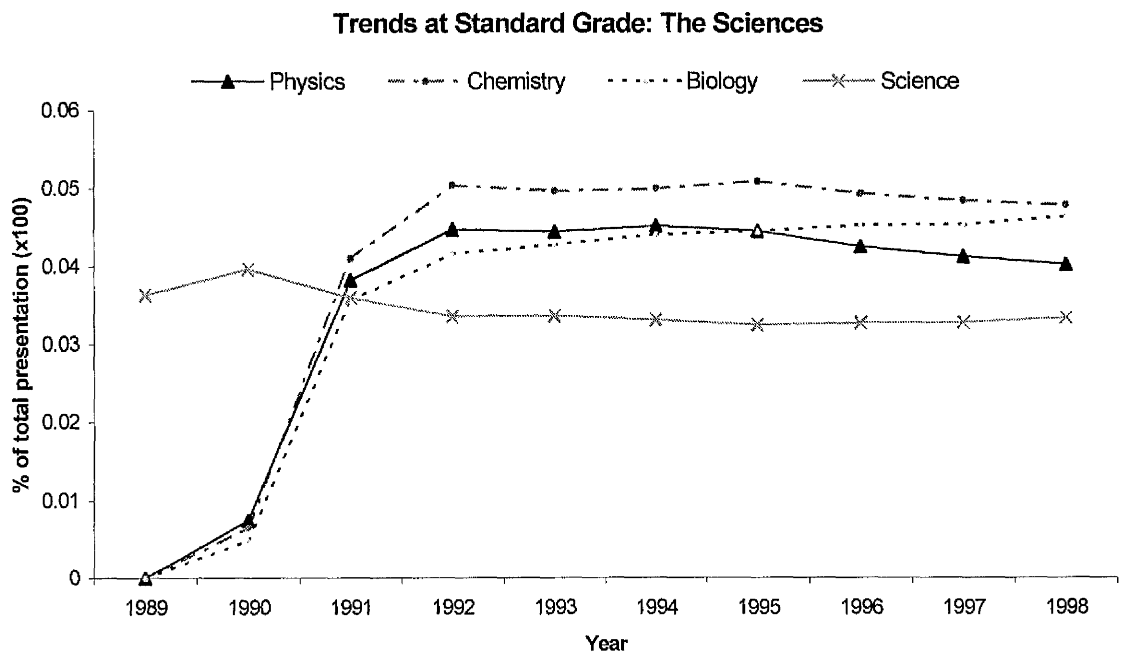
"*The declining popularity of science is a well- known fact. The number of 18-year-olds taking science and math at A-level fell from 42% in 1963 to just 16 % in 1993...*" (Durrani, 1998). Within the sciences, Physics is considered as the most problematic area and Physics traditionally attracts fewer pupils than Chemistry and Biology. However, in Scotland the situation in school science subjects and, in Physics in particular, does not match this generally accepted picture.

In the general analysis of the situation in Physics in English schools, Osborne, Driver and Simon (1998) suggested that "*Physics and Mathematics at [school] are only taken by students who do well and are not taken as incidental or additional subjects*". In Scotland the situation in Physics seems to be different. The statistical data about entries and passes at Higher Grade for Scotland (Scottish Examination Board, examination statistics, 1992-1999) show that Physics for many years has been, and still is, the fourth most popular subject after English, Mathematics and Biology. Among English pupils, Physics is perceived as rather an "elite" subject, which is viewed as conceptually very difficult and only suitable for exceptionally able pupils (Osborne, Driver and Simon, 1998), while, in Scotland, Physics is perceived as rather an ordinary school subject which is open to a very large number of pupils. The distributions for entries in Higher Grade for the three science subjects (Physics, Chemistry and Biology) for the last 36 years are shown in the Graph 6-1 below. (The distributions for entries in Standard Grade Physics, Biology, Chemistry and Science are shown in the Graph 6-2).

Graph 6-1: Distribution of entries in Higher Grade Physics, Chemistry and Biology



Graph 6-2: Distribution of entries in Standard Grade Physics, Chemistry, Biology and General Science



The popularity and high number of presentations in Physics at Higher Grade in Scotland during the last ten years may be considered as a reflection of the popularity of the Standard Grade Physics course. The Standard Grade course was designed to be a course that can be seen to be both relevant and useful to people in their normal lives. It was introduced in Scotland in 1991. Based on developments in Holland, the Standard Grade Physics course was mainly designed as an applications-led course where the applications came first, followed by the principles. For example, the operation of an electric motor would be followed by the principles of electromagnetism (McCormick, 2000). It can be seen from the Graph 6-1 above that, in the two years following the introduction of Standard Grade Physics, there was a sharp increase in the number of presentations in Physics at the Higher Grade, and since then Physics has attracted more pupils than Chemistry in Scotland at Higher Grade.

Features of this study

In much work conducted with secondary school pupils of different ages it has been revealed that interest in Physics declines as students grow older (see p. 46). In this research study, a cross-age analysis (measurement at only one time with students of different age) of pupils' attitudes towards school science and Physics courses has been performed. The aim of this study was to investigate the patterns of pupils' attitudes towards school science and Physics courses for groups of pupils currently engaged in doing these subjects.

The general cross-age picture of pupils' attitudes towards science and Physics lessons can be considered as an attempt to take a series of snap-shots of attitudes at various stages in the school curriculum. These attitudes can be compared at the different stages although care must be taken in such comparison to allow for varying degrees of self-selection. From the cross-age picture of attitudes it may be possible to judge the success or failure of different science teaching approaches in promoting and maintaining pupils' positive attitudes towards the subjects at different stages of schooling.

By looking at attitudes towards science and Physics, and relating them to pupils' choices to study or leave Physics/science, it is hoped to show areas of curriculum strength and weakness.

It can be suggested that the higher the level of pupils studying Physics the more positive are their attitudes towards Physics, since they tend to be a more self-selected and more dedicated to Physics population than their "lower level" peers.

The present study has been conducted with a population of 876 Scottish school pupils, covering an age range from 11 to 18, both from primary and secondary school levels (see p. 56 for full data). Attitudes of primary school pupils and S2 secondary school pupils towards their science lessons, and attitudes of S3, S4, S5/S6 pupils towards their Physics lessons have been investigated.

Special attention was given in this work to the so-called "problem of girls in Science/Physics" and all the analyses have been performed separately for boys and girls.

Since the research has been carried out in Scotland, some words need to be said about the Scottish School educational system, which is different from the rest of the UK.

6.2 Scottish School Educational System

School education in Scotland is distinct from the rest of the United Kingdom. Scottish primary education is of seven years duration (from age 5 to 12; P1-P7), and secondary education is of four compulsory years (from age 13 to 16; S1-S4) which can be followed by one or two further years (from age 17 to 18; S5/S6). Secondary school students sit a broad range of up to eight Standard Grade examinations at age sixteen at the end of the Fourth Year (S4) and then typically around five Highers at the end of the Fifth Year (S5). Many school students stay for a further year of study in the Sixth Year (S6) where they may repeat Highers to improve their grades, study new Highers or study for the Certificate of Sixth Year Studies (CSYS) recently replaced by Advanced Higher, a more in-depth qualification.

Entry to higher education in Scotland is based on the results gained at the Higher Grade examinations. Currently about 80 per cent of Scottish school students stay for S5 or undertake equivalent study at a further education college (National Committee of Inquiry into Higher Education, 1998). Thus Scottish school education ensures a broader education and later specialization than in the rest of the UK where students around age 16 may choose typically a maximum of three subjects, to which they will be committed for two years and this will narrow their choice of university.

6.3 Attitudes of primary pupils towards science

The decision to include primary school children in the present work was taken in order to explore the attitudes towards and perceptions of science and Physics formed by pupils in the last years of their primary schooling and to compare them to attitudes and perceptions held by S2 secondary school pupils. Special attention has been devoted to perceptions held by boys and girls at these stages.

About fifteen years ago science was not a compulsory part of primary school education in either England or Scotland. Following the 1980 HM Inspectors' Report on Learning and Teaching in Primary 4 and Primary 7 in Scotland, which drew attention to the extent to which science was neglected in primary schools, there have been a number of initiatives aimed at improving the provision of science. In some research work following this report and conducted with primary children, very positive attitudes towards and interests in science were revealed among children at these stages (Hadden, 1981). Curiosity and wonder is awakening in every child at the primary school age and that is why science naturally attracts them. In this context, "*what an opportunity is being missed for enriching the education of pupils in primary school by the omission of the direction of this curiosity and wonder in to areas in which it could develop further*" (Hadden and Johnstone, 1982). As a part of the longitudinal work conducted at primary and secondary schools in Scotland, Hadden (1981) investigated the views of secondary school teachers and found that many of them believed that a "*very real initial advantage in introducing incoming pupils to the world of science is the evidence of interests and enthusiasm for science which pupils bring from primary school*".

Advantages of early science education have been discussed in other early work (Bottomley, 1979). By the middle of the 1980s the importance of introducing science as a part of the primary curriculum was widely recognised and the Department of Education and Science (England and Wales) in their Science 5-16 Policy Statement (1985) declared that "*all pupils should be properly introduced to science in the primary school*" and assured that "*the results will justify that effort*". In Scotland, Environmental Studies was established in primary schools to give pupils an introduction to the nature and language of science. The National Guidelines for Environmental Studies 5-14 for Scotland (1985) stated that this implementation should "*result in more pupils being introduced systematically to an appropriate science experience in primary school as well as providing better continuity of provision across the primary/secondary interface*". The Equal Opportunities Commission (1982) had earlier suggested that primary science might be of particular benefit to girls and might solve some of the problems of girls in secondary school science.

Over many years (including the time when there was no science in primary school and after science became a part of the primary school curriculum) it has been revealed that primary pupils normally have very strong positive attitudes towards science, with very marked favourable attitudes to the social benefits that can accrue from the work of scientists (Hadden and Johnstone, 1982; Graig and Ayres, 1988; Stark and Gray, 1999). Primary children, particularly those at the latter stages of their primary school, were found to be very motivated to learn more science in secondary school and "*would have a go at almost anything put in front of them, and would tackle questions which they were unlikely to meet in their formal school setting*" (Stark and Gray, 1999). These views, together with the general expressions of interest in science were found to be common for all groups of primary pupils, when separated by level of intelligence or socio-economical factors, or gender (Hadden and Johnstone, 1982).

In interests towards traditional science subjects areas, like Chemistry, Physics and Biology, it was found that primary boys showed little variation in interests towards these areas, while primary girls revealed clear preferences for Biology and its topics when compared to Chemistry and Physics. In general, boys' interests in Physics topics were found to be significantly greater than girls' (Graig, Ayres, 1988).

6.3.1 Primary pupils' attitudes towards science lessons

Primary school pupils do not have separate science lessons in their primary school course in Scotland. They learn "science" as a part of their environmental studies course. There is therefore a certain degree of difficulty in investigating the effects of primary science. There seems to be no clear consensus about what counts as a primary science. That is why, before asking pupils to evaluate their attitudes towards science lessons, some examples of science related activities and topics, mainly related to Physics, were introduced to pupils and later the analysis of pupils interest to those topics was performed.

A semantic-differential method was employed to judge the pupils' attitudes. There is an example showing how the question was presented to pupils.

Topics like "how a musical instrument works", "why we usually have a rainbow after the rain", "why the use of X-rays can be harmful for the human body" can be explained and discussed in ***science*** *lessons. So, the part of your Environmental Studies lessons where you study problems like those above we will further call* ***science*** *lessons.*

What are your opinions about your ***<u>school science lessons</u>****?*

I like science lessons	▢	▢	▢	▢	▢	▢	I hate science lessons
boring lessons	▢	▢	▢	▢	▢	▢	interesting lessons
I enjoy the lessons	▢	▢	▢	▢	▢	▢	I do not enjoy the lessons
easy lessons	▢	▢	▢	▢	▢	▢	complicated lessons
important subject	▢	▢	▢	▢	▢	▢	useless subject

(see Appendix A, questionnaire P6/P7, question 4)

In the example above, a six-point scale was used. Pupils' responses were grouped into three categories (positive responses, neutral responses and negative responses). Comparisons were made between age groups, and between boys and girls. The chi-square statistic was employed to test for significant difference between age groups and between boys and girls.

The primary school pupils who participated in the present research were selected from a single very large primary school in the central part of Scotland. The location of the school and the population of its pupils was thought to give a reasonably typical crosssection of the Scottish school population. This choice of school was based on advice from a local educational adviser, the school having a highly balanced view of the plan of science in the curriculum. The total number of P6/P7 pupils who participated in the study was 142, 68 girls and 74 boys.

The Table 6-3 below provides the distribution of pupils' attitudes towards different aspects of their science lessons separately for 74 boys and 68 girls.

Table 6-1: Primary P6/P7 pupils' attitudes towards science lessons

Girls (N=68) Boys (N=74)	Positive %	neutral %	negative %	χ^2	Significance	df	favoured
	I like science lessons		*I hate science lessons*				
Girls	66	34	0				
Boys	72	19	9	0.59	ns	1	
	interesting lessons		*boring lessons*				
Girls	57	40	3				
Boys	70	18	12	10.68	1%	2	Boys
	easy lessons		*difficult lessons*				
Girls	25	53	22				
Boys	36	38	26	3.40	ns	2	
	I enjoy the lessons		*I do not enjoy the lessons*				
Girls	69	31	0				
Boys	64	24	12	0.22	ns	1	
	important subject		*useless subject*				
Girls	76	18	1				
Boys	70	22	8	1.36	ns	1	

Note in this Table 6-3 and in the remaining Tables of this Chapter

- df is a "degree of freedom"
- "ns" means "not significant"
- the lower df is used to avoid frequencies less than 4.

Table 6-1 shows that attitudes towards science lessons were found to be very positive among primary girls and boys, and, moreover, both genders considered science as an extremely important subject. The only difference between girls' and boys' attitudes towards their science lessons was found regarding levels of interest towards lessons. Even though girls were found to be very positive about lessons, lessons appeared to be significantly more interesting for boys than for girls, although the views of boys were more polarised.

The findings of this work are fully consistent with results reported before science was introduced as a part of the primary school curriculum in Scotland: although girls are as positive as boys in their attitudes towards science at primary school age, nevertheless the lessons appear to be more interesting for boys (Hadden and Johnstone, 1982). It looks like the situation, which was highlighted more than 20 years ago, still occurs today. Gardner (1975) suggested that the reason for such a bias in favour of boys is probably in the content of science lessons, which tends to be more masculine as pupils move from one level to another. To generate and maintain girls' interests towards science it is important to show the social context of science at every stage of school education, starting from a very early stages of primary school (Smail, 1984; HM Inspectors of school report, 1994).

6.3.2 *Pupils' perceptions of self in science lessons*

This question aimed to find out how pupils feel towards their progress and personal development in science lessons and their general perceptions of self in science. Exactly the same method as for evaluating pupils' attitudes towards science lessons was employed to get pupil responses (see p. 70). The example of the question is given below:

How do you feel yourself about your school Physics course?

I feel I am coping well	☐	☐	☐	☐	☐	☐	I feel I am NOT coping well
I learn a lot of new	☐	☐	☐	☐	☐	☐	I learn nothing new in science lessons
I am NOT obtaining new skills	☐	☐	☐	☐	☐	☐	I am obtaining a lot of new skills
I hate doing experiments	☐	☐	☐	☐	☐	☐	I am enjoying doing experiments
I like the teacher	☐	☐	☐	☐	☐	☐	I dislike the teacher

The way of grouping the data and their analyses were the same as described before (see p. 70).

The Table 6-2 below shows the distribution of pupils' responses presented separately for boys and girls.

Table 6-2: Primary P6/P7 pupils' perceptions of self in science lessons

Girls (N=68) Boys (N=74)	positive %	neutral %	negative %	χ^2	significance	df	favoured
	I feel I am coping well		*I feel I am not coping well*				
Girls	69	26	1				
Boys	77	20	3	0.48	ns	1	
	I learn a lot of new in science lessons		*I learn nothing new in science lessons*				
Girls	90	6	1				
Boys	74	20	5	8.11	1%	1	Girls
	I am obtaining a lot of new skills		*I am not obtaining new skills*				
Girls	69	22	6				
Boys	58	34	8	2.66	ns	2	
	I am enjoying doing experiments		*I hate doing experiments*				
Girls	85	9	3				
Boys	84	9	7	0.73	ns	2	
	I like the teacher		*I dislike the teacher*				
Girls	62	26	4				
Boys	62	23	15	4.32	ns	2	

The following picture has emerged from the analysis of pupils' attitudes towards and perceptions of self in science lessons: in primary school, both boys and girls like science lessons and find them enjoyable. Both girls and boys feel that they are

- coping well,
- enjoying doing experiments,
- obtaining a lot of new skills,
- like their teacher and
- learning a lot of new information in their science lessons.

The latter is especially true for girls.

6.3.3 P6/P7 pupils' intentions towards science in secondary school

As it was shown above, primary P6/P7 pupils were found to be very optimistic and positive about science lessons which they have in primary school as a part of their Environmental Studies course. Those pupils were also found to be looking forward to studying more about science in secondary school: 96 per cent of girls and 89 per cent of boys expressed their interest and desire to study science at secondary school level.

Table 6-3: Distribution of primary boys and girls according their intentions towards studying science in secondary school

	Primary P6/P7	
Would you like to study more science in secondary school?	Girls (N=68)	Boys (N=74)
YES	96%	89%
NO	4%	11%

Looking at the data from the Table 6-3, it is obvious that there is little difference in the intentions of boys and girls towards studying science in secondary school. The majority of primary P6/P7 boys and girls would like to study more science in secondary school. These results are in agreement with previously reported data by Hadden and Johnstone in 1982 (before science became part of the primary education in Scotland), Graig and Ayres in 1988 (shortly after science became a part of primary school education in England). Both studies indicated strong interest and motivation of primary school pupils to study more science in secondary school. In the longitudinal work of Graig and Ayres (1988), it was even found that girls expressed more interest in studying science further at school than boys. In the present study, no significant difference was found between boys' and girls' intentions about science. However, as it can be seen from the Table 6-3 above, girls were extremely positive about learning science: 96 per cent of them would like to study more science in secondary school.

An analysis of factors motivating primary pupils to learn more science in secondary school was carried out. After pupils were asked: *"Would you like to study more science in secondary school?,* they were also asked to give reasons for their opinions (see Appendix A, questionnaire P6/P7, question 6). No differences were found between boys and girls. For the total number of 142 pupils five broad suggestions explaining pupils' interests in learning more science in secondary school emerged with response rates higher than 10%, (see Appendix G, p.1 for full data). These reasons (although the first one is not really a reason), using the language of pupils, were the following:

	%
"I want to learn more about science in secondary school"	26
"It is interesting"	23
"I enjoy doing experiments"	18
"I like and enjoy science"	14

"Science is fun" 12

These five reasons (factors) can be grouped in to the following three categories:

- general interest towards science;
- enjoyment of science lessons;
- enjoyment of doing experiments.

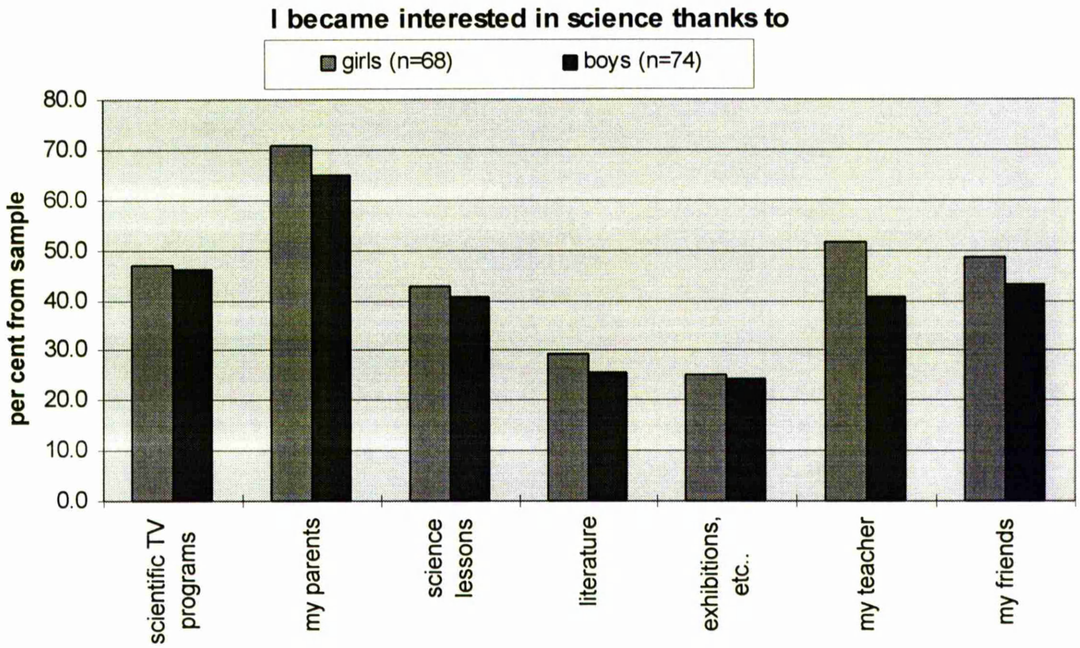
These factors can be considered as the major determinants of primary pupils' interest towards studying science in secondary school. The last two factors have an obvious connection to primary school science lessons.

Only 4 per cent of girls and 11 per cent of boys would not like to study science further in secondary school (see data in the Table 6-3 above). Because these percentages are so low, it is difficult to draw any conclusion about the reasons why these pupils did not wish to study science further.

In general, the results obtained in the present study and the data reported almost 20 years ago by Hadden and Johnstone (1982) in their longitudinal study with almost 1000 Scottish primary stage pupils are fully consistent. It is really interesting to note that pupils' views now are very similar to those views reported by Hadden and Johnstone when science was not a part of the primary science curriculum. The significant majority of primary age pupils today, as well as 20 years ago, like science in primary school and expect to learn more about it later in their secondary school course. Pupils expect that in secondary school science should be "an interesting personal activity with an enrolment in exciting experiments which would results in discovery of knowledge" and "how things work" (Hadden, Johnstone, 1982).

Another outcome for the present work is worth mentioning. Pupils' interest in science at primary stage was found to be generated mainly by parents and this was true both for boys and girls. The same results were reported by Hadden, 1981. The factors that influence pupils' interests towards science are shown on the Graph 6-3. It should be pointed that pupils could indicate as many factors as they wished. (The full data are in the Appendix G, p. 2):

Graph 6-3: Factors which influenced pupils' interests towards science.



The important role of parents in generating and maintaining primary pupils' interests towards science has been stressed by Walford (1983), George and Kaplan (1998). Parents were found to be playing significant direct and indirect roles in forming their children's attitudes towards science through their personal attitudes as well as through different activities in which they involve children, like museum visits, book reading, explanations and discussions. The role of parents was found to be especially important in generating girls' interests towards science and their choice of future science related careers: "*... if we wish to encourage girls to consider a science-related job it is necessary to encourage their parents too. Parents evenings, meetings and discussions need to be held which enable parents to see the possibilities in science for their daughters as well as sons*" (Walford, 1983).

One question in the questionnaire aimed to find out in what kind of activities in secondary school primary pupils want to be involved (see Appendix A, Questionnaire P6/P7, question). It was found that after "playing in a sport team" the second most interesting and exciting activity to do in secondary school for boys was "doing scientific experiments" where boys demonstrated significantly higher interest than girls. Girls valued "cooking" and "learning foreign languages" higher than "doing scientific experiments". (The full data regarding this analysis are in the Appendix G, p. 3).

The influence of primary school science has been observed while analysing images pupils have of scientists. 89 per cent of boys and girls have agreed that "scientists should wear goggles while working" (full data are in the Appendix I, p. 1). This stereotype reflects a classroom science experience when pupils are likely to follow some safety procedures like wearing goggles. As it was demonstrated recently by Newton (1998), modern pupils still have very strong stereotypes about science and scientists, almost unchanged for the last 20 years. Most children at age 4-11 see scientists mainly as men, often bearded and balding, wearing spectacles and in white laboratory coat, doing chemistry (Hadden, Johnstone, 1983; Newton and Newton, 1992). It is interesting to stress that children's conceptions of scientists and science show remarkable similarities to those of children in the USA, Canada, Europe, Australia and new Zealand (Newton and Newton, 1992).

6.3.4. Summary

In general, the analyses of primary pupils' attitudes towards science revealed that modern primary school pupils who have been taught science as a part of the primary school curriculum in Scotland look very similar to those primary school pupils 20 years ago who did almost no formal science in their primary school education. Modern girls and boys as well as girls and boys from "pre-primary science" times were found to be very positive about science and were very interested in learning more science in secondary school. Parents are still found to be playing the main role in generating pupils' interests towards science. Some stereotypes regarding the image of scientists revealed 20 years ago still exist and are very strong among modern primary school pupils.

Following these observations it looks like out-of school activities and parents play a significant role in generating primary pupils' interests towards science and in building pupils' concepts of science and scientists. However, this does not diminish the role and importance of primary science education: upper primary pupils like science lessons and feel good about doing science at school, especially experiments. Science lessons in primary school were among the significant factors generating pupils' interests towards learning more science in secondary school.

6.4. S2 students' attitudes and perceptions in science

The next group of pupils who participated in the present research study was second year secondary school pupils (S2). In Scotland all pupils take science during the first two years of their secondary schooling (S1 and S2). The S1 and S2 science course is taught as a " *fully harmonised course delivered to the class by one teacher rather than three (*Physics, Biology and Chemistry*). This format, it was argued, reinforced the unity of the subject and created the opportunity for consistent teaching and assessment"* (MacGregor, 2000). The majority of pupils are taught in mixed ability classes and follow the course that " *has a balanced coverage of key factors and ideas from biology, chemistry and Physics*" (MacGregor, 2000). Some of these assertions are perhaps open to questions.

In some research work, however, it has been observed that, in the transition from upper primary to secondary school level, some "erosion" of pupils' attitudes towards science takes place. It was shown that the very positive attitudes to science which appeared to be held by the vast majority of pupils at primary school stage had eroded at significantly different rates according to the secondary school, attended by the pupils (Hadden, Johnstone, 1983; Graig and Ayres, 1988). Some general trends were observed in work done by Bottomley (1979), Hadden (1983), Graig and Ayres (1988), Stark *et al.* (1997), Stark and Gray (1999). The following summary gives an overall picture of findings derived from the work done after 1985, when science has been introduced in primary schools in the UK.

- The amount of science done in primary school has no influence on pupils' further level of interest in science in secondary school (Graig and Ayres (England), 1988);
- A number of pupils, both girls and boys, who had shown high levels of interest in science at primary school, showed very low levels of achievement in the first year of secondary school (Graig and Ayres (England), 1988; Stark and Gray (Scotland), 1999);
- Levels of interest in science among girls, which at primary school had been sometimes even higher than those of boys, appears to have dropped

considerably in the first year of secondary school (Graig and Ayres(England), 1988);

- Girls who had studied substantial amounts of science in primary school ("high science girls") did not express stronger interest in secondary science than those who have studied less science in primary school ("low science girls"). In fact, it was found that "high science girls" interest in secondary science was even lower than that of "low science girls"(Graig and Ayres (England), 1988);
- In assessment, the performance of pupils at the primary stages has been regarded as satisfactory, although not ideal, while at the S2 secondary stage (13/14 years) performance has been regarded as unsatisfactory and giving course for concern (Stark and Gray (Scotland),1999);
- In secondary school courses, boys indicated a higher level of interest than girls in both Physics and Chemistry topics but they still displayed less variation between subject areas than girls, similar to primary school. Girls continued to express a strong interest in Biology topics (the same as at primary school), but their interest in Chemistry and Physics topics appeared to have weakened considerably during the first year of secondary school (Graig and Ayres (England), 1988);
- Physics topics at secondary school remained much more popular with boys than with girls (Graig and Ayres (England), 1988).

In the work of Hadden and Johnstone (1983), where longitudinal observation of about 1000 Scottish primary school children in their transition from upper primary to secondary school was carried out, it was showed that "*erosion of interest in science was due more to the erosion of girls' attitudes to science than the boys*". The authors noted that "*differences between boys' and girls' attitudes to science detected at the early stage [of secondary school] were not apparent before exposure to secondary school science*".

6.4.1. S2 pupils' attitudes towards science lessons

The results of the present work are fully consistent with those results obtained by Hadden and Johnstone (1983), despite the fact that since 1985 science has been taught as a part of primary school curriculum (National Guidelines for Environmental Studies 5-14).

373 S2 secondary school pupils participated in the present research study from three randomly selected schools from the central part of Scotland (see Chapter 5, p.56). Pupils' attitudes towards their school science lessons were investigated and compared to attitudes hold by Primary P6/P7 pupils. The same method was used as for evaluation of Primary pupils' attitudes and the same method of analysis the data was applied as described before (see p. 70).

It was observed that at the secondary school stage, the divergence of boys' and girls' attitudes towards science lessons appeared, where girls' attitudes appeared to be significantly less positive than boys. The distribution of percentage frequency of S2 pupils' responses on attitudes towards their science course lessons is shown in the Table 6-4 below, with statistical comparisons between boys and girls being shown.

Table 6-4: S2 pupils' attitudes towards science lessons

Girls (N=194) Boys (N=189)	positive %	neutral %	Negative %	χ^2	Significance	df	favoured
	I like science lessons		*I hate science lessons*				
Girls	45	42	13				
Boys	61	34	5	13.01	1%	2	Boys
	interesting lessons		*boring lessons*				
Girls	38	44	18				
Boys	41	51	8	8.54	5%	2	Boys
	easy lessons		*complicated lessons*				
Girls	22	65	13				
Boys	22	63	15	0.33	ns	2	-
	I'd like to spend more time on science		*I'd like to spend less time on science*				
Girls	18	52	30				
Boys	28	56	16	12.58	1%	2	Boys
	important lessons		*useless lessons*				
Girls	49	40	11				
Boys	57	37	6	4.19	ns	2	-
	enjoying lessons		*boring lessons*				
Girls	40	47	13				
Boys	52	40	8	6.35	5%	1	Boys

It looks as if, at the secondary school level, girls do not enjoy science lessons, do not find them interesting and do not want to spend as much time on science as boys do.

From the analysis of S2 pupils' perceptions of self in science lessons, it was found that girls' feelings about their ability to cope with the science course were significantly lower than boys, and significantly more boys consider science as 'definitely "my" subject', although girls were found to be enjoying practical work more than boys. The full data of S2 pupils' perceptions of self in science lessons are shown in the Table 6-5.

Table 6-5: S2 boys' and girls' perceptions of self in science lessons

Girls (194) Boys (189)	positive %	neutral %	negative %	χ^2	significance	df	favoured
	I feel I am coping well		*I feel I am not coping well*				
Girls	55	40	5				
Boys	62	29	9	6.35	5%	2	Boys
	I am enjoying subject		*I am not enjoying subject*				
Girls	51	38	11				
Boys	54	37	9	0.57	ns	2	
	I am obtaining a lot of new skills		*I am not obtaining new skills*				
Girls	46	46	8				
Boys	53	43	4	3.68	ns	2	
	I find it very hard		*I find it very easy*				
Girls	22	67	11				
Boys	24	62	14	1.23	ns	2	
	I am enjoying practical work		*I hate practical work*				
Girls	72	19	9				
Boys	51	41	8	22.48	1%	2	Girls
	I like the teacher		*I dislike the teacher*				
Girls	43	40	17				
Boys	40	48	12	3.25	ns	2	
	It is definitely "my" subject		*It is definitely not "my" subject*				
Girls	15	56	29				
Boys	33	53	14	23.12	1%	2	Boys

In his review of literature, Gardner (1975) observed that, science lessons become more "masculine" in the course of time, and he linked an observed decline of girls' interests towards science lessons at secondary school with this trend. In the present work it was observed that two years after primary school:

- boys like science lessons more than girls;

- boys want to spend more time on science lessons than girls do
- boys feel that they are coping better than girls.

Nothing like this was observed at the primary school stage where both boys and girls were similar in their very positive attitudes towards science lessons and in their very positive perceptions of self in science lessons.

6.4.2. Comparison of Primary and S2 pupils' attitudes

The comparison of attitudes towards science lessons and the concepts of self in science lessons was carried out by looking at pupils of primary and secondary school separately for both sexes. A summary of the results is given in the Tables 6-6, 6-7 below:

Table 6-6: Comparison of girls' attitudes towards science lessons (P6/P7 and S2)

P6/P7 Girls (N=68) and **S2 Girls** (N=194)	χ^2	**significance**	**df**	**level more favoured**
like lessons/hate lessons	7.02	5%	2	P6/P7
Interesting/boring	7.45	5%	2	P6/P7
easy/complicated	4.03	ns	2	-
important/ useless	16.02	1%	2	P6/P7
enjoying/boring	8.11	1%	1	P6/P7

Table 6-7: Comparison of boys' attitudes towards science lessons (P6/P7 and S2)

P6/P7 Boys (N=74) **S2 Boys** (N=189)	χ^2	**significance**	**df**	**level more favoured**
like lessons/hate lessons	6.41	5%	2	P6/P7
interesting/boring	23.92	1%	2	P6/P7
easy/complicated	13.51	1%	2	P6/P7
important/ useless	5.46	ns	2	-
enjoying/boring	9.35	1%	2	P6/P7

It can be seen from the Table 6-8 and the Table 6-9 that even though secondary school boys consider science lessons as important as primary school boys, and secondary school girls do not find their current science lessons more difficult than girls in primary science, in general, in primary school, both girls' and boys' attitudes towards science lessons look much more positive than attitudes of secondary school boys and girls.

Comparison analyses of pupils' perceptions of self in science lessons revealed that both girls and boys in primary school science lessons feel much better about themselves than girls and boys doing S2 science course in secondary school (see Tables 6-8, 6-9 below).

Table 6-8: Comparison of girls' perceptions of self in science lessons (P6/P7 and S2)

P6/P7 Girls(N=68) **S2 Girls** (N=194)	χ^2	**significance**	**df**	**level more favoured**
coping /not coping well	5.76	5%	1	P6/P7
obtaining/NOT obtaining lots of new skills	12.83	1%	2	P6/P7
enjoying/hate practical work	6.58	5%	1	P6/P7
like/dislike the teacher	11.26	1%	1	P6/P7

Table 6-9: Comparison of boys' perceptions of self in science lessons (P6/P7 and S2)

P6/P7 Boys (N=74) **S2 Boys** (N=189)	χ^2	**significance**	**df**	**level more favoured**
coping /not coping well	6.05	5%	2	P6/P7
obtaining/NOT obtaining lots of new skills	2.96	ns	2	-
enjoying/hate practical work	26.69	1%	2	P6/P7
like/dislike the teacher	14.05	1%	2	P6/P7

In general, it was observed that primary school pupils valued science lessons more highly than secondary school pupils in the majority of the dimensions assessed. Moreover, primary pupils' attitudes towards their teacher were found to be significantly higher than attitudes of secondary school pupils. The erosion of girls' and boys' attitudes towards science lessons in transition from primary to secondary school observed by Hadden (1981) is still taking place today. Moreover, as it was about 20 years ago, the "erosion" is more strongly marked among girls than among boys.

There can be several possible reasons for the situation:

1. *Content of the S1 and S2 courses:*

In some work conducted in Scotland, the lack of continuity between primary and secondary school science courses was criticised (Stark and Gray, 1999). It is a general concern that secondary schools are adopting a "fresh start" approach and failing to take account of pupils' primary school experience (SOED, 1994). In the 1994 report of HM Inspectors of Schools in Scotland it has been pointed that there should be a *"review of* *existing practice at S1/S2 to build on pupils' primary school experience and thus offer pupils a greater degree of challenge*".

2. <u>*Teacher:*</u>

According to a review carried out by HM Inspectors of schools in 1994, more than 60 per cent of science teachers in Scotland are above 40 years old and many of them are teaching content which they had not covered in their university training. Moreover, it is a very common situation where a teacher with a degree in one science subject, very often in Biology, is required to cover aspects of other science subjects, like Chemistry and Physics in S1 and S2 courses. Teacher's own attitudes towards science have a very strong influence on their pupils' attitudes (p. 52). Within the school, *"teachers [were found to be] the greatest influence on pupils' interests towards science*", (George and Kaplan, 1998). The teacher was found to be playing a very important role in stimulating and maintaining girls' interests and positive attitudes towards science (Coulson, 1992; Seymour and Hewitt, 1997). Strong positive associations exist between teacher and attitude towards science lessons for S2 pupils, and this association is stronger for girls.

3. <u>*Adolescence:*</u>

It has been observed that a general decline occurs in interests towards science as pupils grow older (p. 46). Some "erosion" from initially highly polarised and favourable view of school subjects [like mathematics and science, for example] was observed in transition from primary to secondary school. Moreover, evidence exists that the erosion is more pronounced in science than it is for mathematics (Hadden, Johnstone, 1983).

Much work clearly needs to be done in the early secondary school and the current research confirms that the problems identified in the past still persist today.

6.4.3. Primary and S2 pupils' intentions towards studying science

In the previous Section 6.3.2 it has been shown that primary school pupils demonstrated a very strong wish to do science in secondary school and no differences were found between boys' and girls' intentions towards it (see Table 6-3, p. 74). The Table 6-10 below compares the data for primary and secondary school pupils' intentions towards studying further science, with boys and girls shown separately.

Table 6-10: Girls' and boys' intentions towards studying further science (P6/P7 and S2)

	Primary school		**Secondary school**	
Would you like to study more science later in your school course?	Girls (N=68)	Boys (N=74)	Girls (N=194)	Boys (N=189)
YES	65 96%	66 89%	127 66%	124 66%
NO	3 4%	8 11%	67 34%	65 34%

From the analyses of S2 secondary pupils' intentions towards studying further science, it has also been found that there are no differences in intentions of boys and girls. However, there is a difference between the intentions of primary and secondary pupils. Significantly fewer secondary pupils wanted to study science further than their younger peers. This can be seen from the Table 6-11 below, where analysis has been done separately for girls and boys from these two age groups.

Table 6-11: Comparison of boys' /girls' intentions towards studying science (P6/P7 and S2)

"I would like to study science subject next year"	χ^2	**Significance**	**df**	**level more favoured**
P6/P7 girls (N=68)/ S2 girls (N=194)	9.31	1%	1	P6/P7
P6/P7 boys (N=74)/S2 boys (N=189)	14.77	1%	1	P6/P7

The survey of secondary school pupils was done in May-June, close to the end of the academic year. At this time S2 secondary pupils normally would select which science subject(s) they wished to study the following year. Since 1984, all pupils have been required to study at least one science up to S4. This means that, even though pupils do not want to study science further in their secondary school, they have to do it for two more years and sit Standard Grade examinations. It is likely that a proportion of S2 pupils will be opting for a Science course simply because they have no other choice. An analysis of S2 pupils' choices of science subject(s) for Standard Grade was carried (Table 6-12 below):

Table 6-12: Science subjects chosen by S2 pupils for Standard Grade.

Subject for Standard Grade	Girls (N=194)	Boys (N=189)	χ^2	significance	df	Preference
General Science, only, %	25.8	33.3	2.6	ns	1	-
Chemistry, only, %	6.2	6.3	0	-	-	-
Physics, only, %	8.8	19.0	8.4	1%	1	Boys
Biology, only, %	27.8	8.5	23.9	1%	1	Girls
Biology + Chemistry, %	11.9	5.3	5.3	5%	1	Girls
Physics + Chemistry, %	10.3	19.6	6.5	5%	1	Boys
Physics + Biology, %	3.1	2.1	-	-	-	-
Chemistry + Biology + Physics, %	2.6	0.5	-	-	-	-
Don't know yet, %	3.6	5.3	0.7	ns	1	-

It can be seen from the analysis above that significantly more boys prefer to study Physics for Standard Grade, while significantly more girls prefer to study Biology. Chemistry can be considered as a rather neutral subject regarding preferences of boys and girls. It has been found that 27.8 % of girls and 27.5 % of boys revealed intentions to take two or three science subjects for Standard Grade. Typically girls prefer to take Biology in combination with Chemistry, while boys prefer to take Physics in combination with Chemistry. Very few pupils of both sexes are thinking of taking all three science subjects (partly because of the options allowed from their timetable), or a Physics and Biology combination.

In general, the number of S2 girls who expressed a desire to take Physics for Standard Grade was 25% (49) and the number of boys was 41% (78) with the ratio of boys to girls equal to 1.6.

The data obtained in this study are consistent with the statistical data about numbers of girls and boys doing Physics for Standard Grade in Scotland. Examination statistics for Scotland (SED 1997) reveals that the pattern of presentation in Physics for Standard Grade is 1 to 2 in favour of boys, while the pattern of presentation in Biology is 2 to 1 in favour of girls, with approximately even numbers of boys and girls in Chemistry. These data paint the picture of gender-related differences in preference of subjects which persists, as it has been observed, from 8 -9 years until the end of schooling (Stark and Gray, 1999). The same picture also takes place in the Higher Grade examinations, where combined pictures of presentations for examination at the end of fifth or six year show the ratio of 1 to 2 in favour of girls in Biology, and 1 to 2 in favour of boys in Physics (SOED, 1997). Statistics for England and Wales shows the ratio of 1 to 3 in favour of boys in GCSE Physics and ratio almost 1 to 5 in favour of boys for GCE Physics (OFSTED, 1994). It is an important observation that, in Scotland, the ratio of boys to girls in Physics, once established at S2 level, stays constant during the years of secondary schooling (Scottish Examination Board, 1994, 95,96; see Appendix J, p.1).

The main reasons for taking Physics for Standard Grade for S2 pupils, both for girls and boys were:

	%
usefulness for a further career	44
interest in the subject	29

(Full data can be seen in the Appendix B, p. 1).

S2 pupils did not want to study Physics for Standard grade mainly because:

	%
subject is boring (not interesting)	48
want to take another science subject	28
Physics is too hard	16

Everywhere in the last three factors girls significantly outnumbered boys. It follows that perceptions that Physics is hard and boring subject are significantly stronger among girls than among boys at this stage. Full data are in the Appendix B, p.1.

6.4.4. Summary

1. It was observed that attitudes towards science lessons and intentions towards studying science are strongly related (the higher the attitudes towards science lessons the more pupils want to study science). Primary pupils were found to hold significantly more positive attitudes towards science lessons than S2 pupils, and it has been observed that significantly more primary pupils were looking forward to studying science further in secondary school than their older S2 peers.

2. Attitudes of girls towards science lessons at S2 were found to be significantly less positive than attitudes of boys. Approximately twice as many boys are attracted to Physics at the S2 stage than girls, and according to the statistical data this ratio persists till the end of schooling. It looks as if the number of girls in Physics is an

issue than the main attention should be paid to late primary and first two years of secondary schooling.

In the work carried out with university Physics students, it has been revealed that the main factors which attract girls as well as boys to university Physics are (see p. 142):

1. interest and enjoyment in subject;
2. good grades at school;
3. good career opportunities;
4. teacher.

Interest and enjoyment appeared to be one of the most important factors determining girls' and boys' choice of studying Physics. However, boys and girls differ psychologically

> *" ...girls are stemming from a world comprised of relationships, a world that coheres through human connections rather than through systems of rules"*
>
> (Gilligan, C. 1982),

and the fields of their interests in Physics should be different to some extent,

> *"just as the leisure activities of boys and girls are already different by the age of 11, so also are their scientific interests. "*
>
> (Johnson and Murphy, 1984, p. 406).

To maintain girls' favourable attitudes towards Physics/Science, the specifics of girls' interests should be taken into account and reflected in the content of science lessons. Results of much research work support this point (DES 1980; Johnson and Murphy, 1984; Smail, 1984; Jorg and Wubbels, 1987). The discussion of this issue will be continued later in the Chapter 7 where girls' and boys' interests towards Physics topics will be considered.

6.5. Standard Grade Physics pupils' attitudes toward Physics

At the end of the S2 secondary science course, pupils have to make their choice of the particular science subject(s) they wish to take for Standard Grade examinations. The next group of pupils involved in this study are those who chose to study Physics for Standard Grade. Pupils have to study Physics for two years before sitting the Standard Grade exams. Students from both S3 and S4 levels have been surveyed.

The total number of S3 pupils who participated in the research was 103 (34 girls and 69 boys) and 152 pupils from S4 group (65 girls and 87 boys). These pupils were selected from five schools in the Central Belt of Scotland (see p. 56 for more data). The ratio of boys to girls for S3 group equal 2.0 and for S4 group 1.4 which approximately reflects the existing ratio of boys to girls at these stages (see Appendix J, p.1).

It should be noted that, although S4 pupils are one year older, more experienced and mature than their younger peers at S3 stage, there is no "qualitative" difference between these two groups. Standard Grade Physics is a two-year course, with no selection after S3.

6.5.1 S3 and S4 pupils' attitudes towards Physics lessons

The same questions which were used with primary and S2 pupils to evaluate their attitudes towards science lessons were used for S3 and S4 pupils to evaluate their attitudes towards Physics lessons (simply the word "science" was changed to word "Physics"). See Appendix A: questionnaire S3 and questionnaire S4 (1997/98) question 3 and questionnaire S4 (1998/99) question 7.

A comparison analysis was performed to find out the differences between:

- S3 boys' and girls' attitudes towards Physics lessons;
- S4 boys' and girls' attitudes towards Physics lessons;
- S3 and S4 pupils' attitudes, separately for girls and boys.

The following results were obtained:

- *S3 boys' and girls' attitudes*;

Only one difference in attitudes of S3 boys and girls towards their Physics lessons was found:

statements	χ^2	***df***	***significance***	***favoured****
lessons easy*/complicated	7.63	2	< 5%	boys

Lessons appeared to be more complicated for S3 girls than boys. The full data are in the Appendix C, p. 3.

■ *S4 boys' and girls' attitudes*;

No differences have been revealed in S4 girls' and boys attitudes towards their Physics lessons. The full data are in the Appendix C, p. 4.

These results make it possible to conclude that there are almost no differences in attitudes towards Physics lessons between boys and girls doing S3 and S4 Standard Grade Physics courses. Standard S3 girls were similar to S3 boys, as well as S4 girls were similar to S4 boys in their evaluations of

- interest towards lessons,
- enjoyment of lessons,
- importance of lessons.

■ *S3 and S4 pupils' attitudes;*

The Table 6-13 below compares S3 girls to S4 girls in their attitudes towards Physics lessons and the Table 6-14 compares S3 boys to S4 boys.

Table 6-13: Comparison of girls' attitudes towards Physics lessons (S3 and S4)

S3 Girls (N=34) **S4 Girls** (N=65)	χ^2	**Significance**	**df**	**level more favoured**
like lessons/hate lessons	2.81	ns	2	-
interesting/boring	4.45	ns	2	-
easy/complicated	1.12	ns	1	-
important/ useless	1.88	ns	1	-
enjoying/boring	5.14	5%	1	S4

Table 6-14: Comparison of boys' attitudes towards Physics lessons (S3 and S4)

S3 Boys (N=69) **S4 Boys** (N=87)	χ^2	**significance**	**df**	**level more favoured**
like lessons/hate lessons	2.97	ns	2	-
interesting/boring	2.39	ns	2	-
easy/complicated	5.42	ns	2	-
important/ useless	4.15	5%	1	S4
enjoying/boring	3.06	ns	2	-

Tables 6-13, 6-14 show that there were almost no differences between S3 and S4 girls' and between S3 and S4 boys' attitudes towards Physics lessons. However, there is a growing of enjoyment from lessons for girls and growing of importance of Standard Grade Physics lessons for boys as they move from S3 to S4.

6.5.2 S3 and S4 pupils' perceptions of self in Physics lessons

Analysis of students' perceptions of self in Physics lessons was performed to compare:

- S3 boys' and girls' perceptions of self in Physics lessons;
- S4 boys' and girls' perceptions of self in Physics lessons;
- S3 and S4 pupils' perceptions, separately for girls and boys.

The following picture was obtained:

- *S3 boys and girls*;

No differences in perceptions of self held by girls and boys taking the S3 Physics course were found. (Full data are in the Appendix D, p. 3).

- *S4 boys and girls*;

One difference between S4 girls and boys was found:

statements	χ^2	***df***	***significance***	***favoured***
Physics is definitely "my" subject	22.94	2	< 1%	boys

Significantly more S4 boys than girls think that 'Physics is definitely "their" subject'. It has been noted that S4 girls and boys have similar and positive attitudes towards Physics lessons. It is likely therefore that some other factor(s) has(ve) influenced such perceptions of S4 girls towards Physics. Social stereotypes considering Physics as a traditionally male-dominated field of activity could be a reason. (The full data regarding these analyses are in the Appendix D, p. 4).

- *S3 and S4 pupils' perceptions*;

Comparison between S3 and S4 perceptions of self in Physics lessons are shown in the Tables 6-15 and 6-16 separately for girls and boys. This comparison revealed that girls are getting more positive about themselves at S4 level in terms of intellectual growth, and obtaining new skills. Boys at S4 level were found to be stronger than S3 boys in their perceptions about Physics as "definitely 'their' subject".

Table 6-15: Comparison of girls' perceptions of self in Physics lessons (S3 and S4)

S3 Girls (N=34) **S4 Girls** (N=65)	χ^2	**significance**	**df**	**level more favoured**
enjoying/not enjoying subject	4.12	ns	2	-
coping /not coping well	0.05	ns	2	-
growing/not growing intellectually	7.15	5%	2	S4
obtaining/NOT obtaining lots of new skills	12.18	1%	2	S4
enjoying/hate practical work	0.01	ns	1	-
getting better/worse in Physics	0.91	ns	1	-
subject is very easy/very hard	7.81	5%	2	S4
It is "my"/not "my" subject	0.08	ns	2	-

Table 6-16: Comparison of boys' perceptions of self in Physics lessons (S3 and S4)

S3 Boys (N=69) **S4 Boys** (N=87)	χ^2	**significance**	**df**	**level more favoured**
enjoying/not enjoying subject	4.58	ns	2	-
coping /not coping well	0.06	ns	2	-
growing/not growing intellectually	0.08	ns	2	-
obtaining/NOT obtaining lots of new skills	4.64	ns	2	-
enjoying/hate practical work	0.17	ns	2	-
getting better/worse in Physics	2.32	ns	1	-
subject is very easy/very hard	4.17	ns	2	-
It is "my"/not "my" subject	9.88	ns	1	S4

In general it was observed that while there are differences between S3 and S4 (in their attitudes towards Physics lessons, or in their perceptions of self in Physics lessons), there is a tendency for significant improvements with age.

6.5.3 S3 and S4 pupils' intentions towards Higher Grade Physics

S3 and S4 pupils were asked about their intentions towards studying Physics for Higher Grade. No differences were found between girls' and boys' intentions from both levels of Standard Grade course (Table 6-17 below).

Table 6-17: Percentage of girls and boys planning to take Higher Grade Physics

	S3		S4	
	No. total	for Higher Grade Physics	No. total	for Higher Grade Physics
Female	34	68% 23	65	92% 60
Male	69	68% 47	87	89% 77
Male/Female ratio for Higher Grade	2.0		1.3	

When surveyed, most of the S4 pupils would have already decided about "their future" regarding to Physics while S3 pupils had a whole year ahead and their plans and intentions have not been fully developed. This might explain the large difference in intentions of S3 and S4 pupils. However, the results obtained for S4 pupils are remarkable: 92 per cent of girls and 89 per cent of boys finishing their Standard Grade Physics course expressed their intentions to study Higher Grade Physics. This might reflect an extremely satisfactory experience of Physics in the Standard Grade Course.

The following factors, which influenced S3 pupils' decisions to study Physics for Higher Grade, were obtained:

	%
useful for a good career	51
good basis for other subjects	36
interests in subject	26
better chance to enter university	12

The main factors, which influenced S4 pupils to take Physics for Higher Grade, were:

	%
"I like Physics"	68
good grades in the subject	56
interest in the subject	44
useful for a good career	31

Students who decide not to take Physics for Higher Grade found Physics either hard or boring or did not need the subject for their future career. Full data can be seen in the Appendix B, pp. 2-3

6.5.4 Summary

1. On the basis of the results obtained it is reasonable to say that the Standard Grade Physics course is designed in such a way to be equally attractive to both girls and boys. It has been found that girls doing Standard Grade Physics course like and enjoy lessons as much as boys do, and girls' feelings about their progress, improvements in subject, intellectual growth, acquiring practical skills, enjoyment of practical work, difficulties in the subject were not different from boys doing the same course of Physics. However, significantly fewer girls than boys feel that 'Physics is definitely "their" subject' after all, at the end of S4 level. This is probably due to gender differences in social stereotypes and expectations. The ratio of boys to girls remains almost constant through the Standard Grade up to Higher Grade.

2. The vast majority of pupils when complete Standard Grade Physics go on to Higher Grade Physics. This can be considered to be a direct outcome of the success of the Standard Grade Physics course.

6.6 S5/S6 Higher Grade Physics students

Up to S4 level, education is compulsory in Scotland. After pupils sit Standard Grade exams they can either leave school for work, or proceed further towards Higher Grade or Certificate of Six Year Studies or to Further Education College. The entrance to Higher Education is based on the results obtained for Higher Grade. Higher Grade Physics was designed to be a traditional content-based syllabus and not application based like Standard Grade. In the Higher Grade principles are taught first, with applications added on.

The number of pupils staying in education beyond S4 is very high in Scotland: about 80 per cent of Scottish pupils stay towards S5 or its equivalent (National Committee of Inquiry into Higher Education, 1998). It is also known that Physics is the fourth most popular subject for Higher Grade in Scotland after English, Mathematics and Biology (Graph 6-1) suggesting that the Standard Grade Physics course is very successful. It has already been noted that the number of pupils who were thinking about studying Physics for Higher Grade Physics was very high. 92 per cent of S4 girls and 89 per cent of S4 boys doing Standard Grade Physics expressed their desire to study Physics further for Higher Grade (Table 6-17).

In the rest of this Chapter, pupils taking the Higher Grade Physics course will be considered and their attitudes and perceptions will then be compared to attitudes and perceptions held by Standard Grade S4 Physics pupils. It should be noted that S5/S6 and S4 pupils are qualitatively different (there has been a selection) and care must be taken while making comparison between S4 and S5/S6 pupils.

The total number of S5/S6 students from the three schools surveyed was 96 (28 girls and 68 boys). This sample was drawn from three secondary schools. S5 and S6 pupils were considered as one group because some students from S6 level may also do Higher Grade Physics as well as S5 pupils.

6.6.1 S5/S6 pupils' attitudes towards Physics lessons

The same question style was used as described before for S2, S3, S4 pupils to evaluate S5/S6 pupils' attitudes towards Physics lessons and students' perceptions of self in Physics lessons. The same method of grouping was used and the same statistical method was employed to make comparison between girls and boys and between different age groups (see p. 70). (Appendix A, questionnaire S5/S6, questions 7, 8).

A comparison between S5/S6 girls' and boys' attitudes towards their Physics lessons shows no differences. (The data are in the Appendix C, p. 5).

However, when S5/S6 pupils were compared to S4 pupils, some differences in favour of S4 pupils were found regarding enjoyment of lessons and their perceived importance. Moreover, S4 boys were also significantly more positive in their interest towards lessons than S5/S6 boys (Tables 6-18, 6-19).

Table 6-18: Comparison of girls' attitudes towards Physics lessons (S4 and S5/S6)

S4 Girls (N=65) **S5/S6 Girls** (N=28)	χ^2	**significance**	**df**	**level more favoured**
like lessons/hate lessons	1.34	ns	2	-
interesting/boring	4.04	ns	2	-
easy/complicated	2.03	ns	2	-
important/ useless	9.81	1%	1	S4
enjoying/boring	9.59	1%	1	S4

Table 6-19: Comparison of boys' attitudes towards Physics lessons (S4 and S5/S6)

S4 Boys (N=87) **S5-S6 Boys** (N=68)	χ^2	**significance**	**df**	**level more favoured**
like lessons/hate lessons	7.81	5%	2	S4
Interesting/boring	15.17	1%	2	S4
easy/complicated	1.86	ns	2	-
Important/ useless	30.27	1%	1	S4
enjoying/boring	13.53	1%	2	S4

Standard Grade Physics looks more interesting, enjoyable and important than Higher Grade Physics, especially for boys. It can be commented that an application-based approach of Standard Grade Physics course looks more appealing to pupils than the principle-based Higher Grade Physics course and this is particularly true for boys.

6.6.2 S5/S6 students' perceptions of self in Physics lessons

Analyses of S5/S6 students' perceptions of self in Physics lessons revealed that significantly more girls than boys feel that they are growing intellectually in their Higher Grade Physics course:

statements	χ^2	*df*	*significance*	*favoured**
I am growing*/not growing intellectually	8.64	1	< 1%	girls

No other differences in perceptions of boys and girls, including perceptions of Physics as "definitely 'my' subject" were found. (The full data are in the Appendix D, p. 5).

Comparisons between S4 and S5/S6 pupils were performed separately for boys and girls and revealed that both S5/S6 boys and girls feel that they are obtaining significantly fewer new skills than their younger peers at Standard Grade. Moreover, S5/S6 girls were enjoying practical work less than girls at S4 level.

Table 6-20: Comparison of girls' perceptions of self in Physics lessons (S4 and S5/S6)

S4 Girls (N=65) **S5/S6 Girls** (N=28)	χ^2	**significance**	**df**	**level more favoured**
coping /not coping well	0.04	ns	2	-
growing/not growing intellectually	2.10	ns	1	-
obtaining/NOT obtaining lots of new skills	12.43	1%	1	S4
enjoying/hate practical work	11.75	1%	1	S4
getting better/worse in Physics	0.21	ns	1	-
It is "my"/not "my" subject	2.99	ns	2	-

Table 6-21: Comparison of boys' perceptions of self in Physics lessons (S4 and S5/S6)

S4 Boys (N=87) **S5-S6 Boys** (N=68)	χ^2	**significance**	**df**	**level more favoured**
coping /not coping well	10.27	1%	2	S4
growing/not growing intellectually	1.72	ns	2	-
obtaining/NOT obtaining lots of new skills	14.00	1%	2	S4
enjoying/hate practical work	4.71	5%	1	-
getting better/worse in Physics	2.71	ns	1	-
it is "my"/not "my" subject	42.70	<0.1%	1	S4

From the analyses done it follows that the principle-based approach of the Higher Grade Physics course has some negative influences on boys' attitudes towards and perceptions of self in Physics. At Higher Grade Physics boys find lessons less interesting, less important, less enjoyable than boys doing the Standard Grade Physics course, and it was observed that S5/S6 boys' perceptions of Physics as "definitely their subject" have weaken significantly after the Standard Grade Physics course. Girls doing Higher Grade Physics do not find lessons as important and enjoyable as Standard Grade Physics girls do, nevertheless their perceptions of Physics were similar to perceptions of S4 girls. S5/S6 girls and boys were found to be similar in evaluation "Physics as definitely 'my' subject". It looks as if context of the Higher Grade lessons had some negative influence of S5/S6 boys' perceptions about Physics, but not on girls' perceptions.

6.6.3 Physics related intentions of S5/S6 pupils

86 per cent of S5/S6 girls and 80 per cent of S5/S6 boys expressed a desire to continue study at University after school. Pupils have been asked to identify subject(s) they might take at University. The distribution of subjects of pupils' choice is represented in the Appendix H, p. 1. Only about 13 per cent of girls (3) and 11 per cent of boys (6) doing S5/S6 Physics course and going to University after school were planning to continue studying Physics at University.

Because sample of the students planning to study Physics at university was low, nothing can be said about the reasons for their decision. Analysis of the level 1 students' responses revealed that the main factors which influenced their choice of a degree subject (Physics) were:

- interest and enjoyment of the subject at school;
- good grades in the subject;
- career perspectives and
- school Physics teacher

(see Appendix O, p.1)

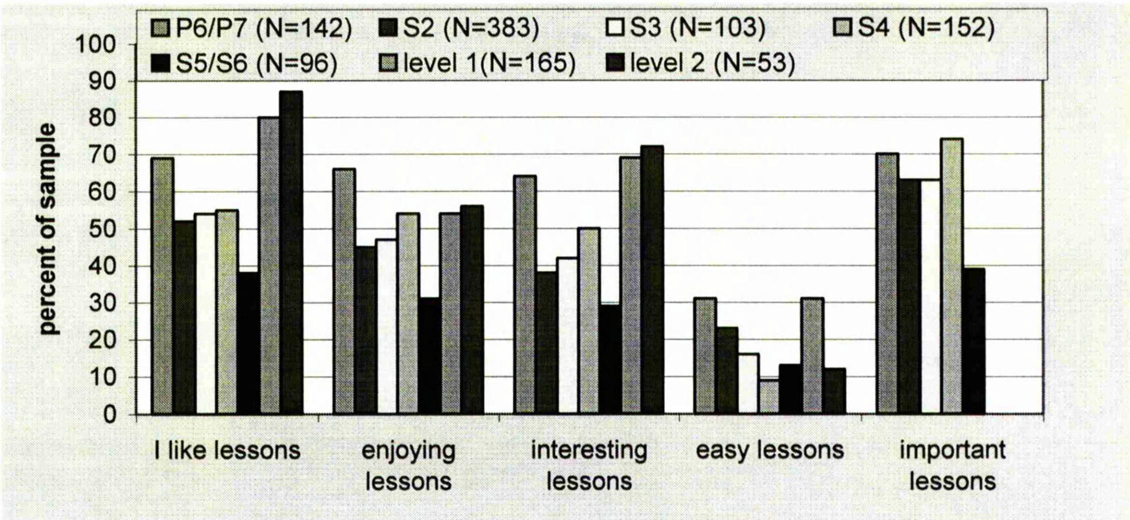
6.7 Summary

6.7.1 Pupils' attitudes and perceptions of self in Science and Physics lessons

A general picture of pupils' attitudes towards their science (P6/P7 primary level and S2 secondary level) and Physics lessons (S3, S4, S5/S6) is shown on the bar chart 6-4 below. On the same Graph 6-4 attitudes of level 1 and level 2 students doing 97/98 Physics course at the University of Glasgow are shown as well.

It must be stressed again that populations of pupils compared were not equal. Primary pupils' and S2 pupils' attitudes towards science lessons have been investigated, where primary pupils do science only as a part of their environmental studies lessons, while S2 do the compulsory course of science in secondary school. S3 and S4 pupils had chosen to take Standard Grade Physics, while S5/S6 had elected to take Higher Grade Physics. Level 1 students are more selected again, and level 2 students represent a group fairly committed to Physics. The general distribution of these pupils' attitudes will show the patterns of attitudes, held by each of the group which are interesting to compare (limitations mentioned above are taken in to account).

Graph 6-4: Pupils'/ students' attitudes towards current Science/Physics course



Note: level 1 and level 2 students have not been asked about importance of school Physics lessons.

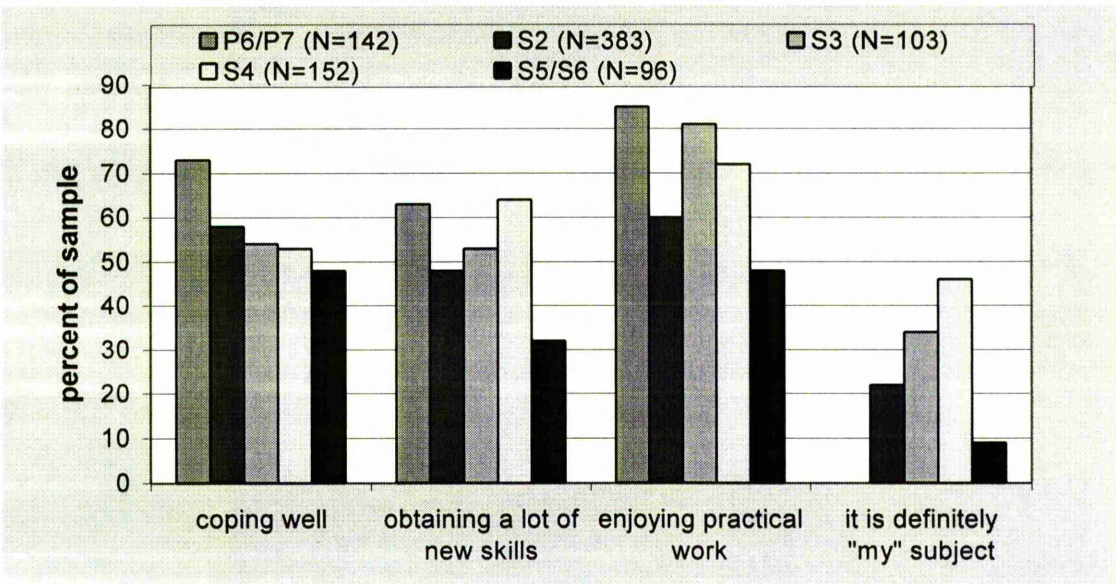
It can be clearly seen from the Graph 6-4 that:

- primary school pupils' attitudes towards science lessons were very positive and significantly more positive than attitudes towards science lessons held by S2 pupils (χ^2=12.57 is significant at 1% when df=2; see Appendix C, p. 6)
- pupils doing Standard Grade Physics were found to be similar about their Physics lessons at both S3 and S4 levels (see Appendix C, p. 6)
- At Higher Grade, lessons look significantly less interesting, less enjoyable, less important than at Standard Grade. Standard Grade S4 pupils' attitudes towards Physics lessons were significantly higher than attitudes of Higher Grade S5/S6 pupils (χ^2=8.46 is significant at 5% when df=2; see Appendix C, p. 6).
- attitudes towards school Physics lessons of level 1 and level 2 students doing Physics course at the University of Glasgow were found to be extremely positive reflecting a group more committed to Physics. It can be seen that

students doing Physics at the university were extremely positive in evaluating their school Physics experience.

The Graph 6-5 below represents the distribution of self-perceptions in Science/Physics lessons for the population of school pupils only.

Graph 6-5: Pupils' perceptions of self in current Science/Physics course



It is clear from the Graph 6-5 that S5/S6 pupils were significantly less positive about themselves in the Higher Grade Physics course than Standard Grade Physics pupils. Higher Grade Physics pupils were also feeling that they were coping not as good as Standard Grade pupils and there is an obvious (and significant at 0.1%) decline in perceptions about Physics as ' definitely "my" subject' among them when compared to S4 pupils (see Appendix D, p. 7). The last decline is mainly due to the decline of S5/S6 boys' perceptions in comparison to S4 boys' perceptions. Discussion about reasons for different perceptions of girls and boys about Physics will be continued in the next Chapter.

Primary pupils look much more positive in their perceptions of self in science lessons than S2 pupils (see Appendix D, p.6-7).

In general two "declines " have been observed in attitudes towards and perceptions in Science/Physics:

- The first "decline" has taken place after the transition from primary to secondary school.
- The second "decline" has taken place after the transition from Standard Grade Physics S4 level to Higher Grade Physics level.

The later "decline" contradicts the supposition done at the beginning of this Chapter 6. The supposition was that the more self-selected the group, the more positive will be the attitudes towards the subject. This is clearly not so when looking at attitudes towards Physics between S4 and S5/S6 groups. (Standard Grade may be far too popular, or Higher Grade Physics course is not popular enough). This result may reflect the importance of syllabus type in promoting pupils' attitudes towards the subject.

6.7.2 Distribution of pupils' intentions towards Science/Physics

The Table 6-22 below summarises pupils' intentions towards studying further Science/Physics;

- P6/P7 pupils' intentions towards studying science in secondary school,
- S2 pupils' intentions towards doing Physics for Standard Grade,
- S3 and S4 pupils' intentions towards doing Physics for Higher Grade,
- S5/S6** pupils' intentions towards studying Physics at University.

The ratio of boys to girls is represented for each category of pupils.

Table 6-22: Intentions of boys and girls towards further studying of Science/Physics

	P6/P7 boys=74 girls=68	**S2** boys=189, girls=194.	**S3** boys=69, girls=34	**S4** boys=87, girls=65	**S5/S6**** boys=55, girls=24
Girls	96% 65	25% 49	68% 23	92% 60	13% 3
Boys	89% 66	41% 78	68% 47	89% 77	11% 6
boys/girls ratio	1.0	1.6	2.1	1.3	2

About 33 per cent of pupils studying Science course at S2 level would like to take Physics for Standard Grade. Standard Grade course retains the vast majority of pupils in Physics and the percentage of those who were planning to do Higher Grade Physics was growing during years of Standard Grade course. Almost all pupils doing Physics for Standard Grade at S4 level were planning to take Physics for Higher Grade. About 11% of pupils doing Higher Grade Physics were planning to continue studying Physics at University level.

On the basis of the evidence collected it can be suggested that the ratio of two to one in favour of boys in Physics can be changed if more girls are attracted to Physics at the S1-S2 stages. The Standard Grade Physics course shows good retention of girls into the Higher Grade Physics.

Chapter 7

Gender differences in interest towards Physics

"If someone tells you that women cannot do science, or are not as good as men, that is not true. Women are different, and science needs different perspectives, and women can provide valuable, different perspectives to science."

[Female, science non-switcher]
Seymour, Hewitt (1997)

The gender differences in attitudes towards science and Physics lessons have been analysed and discussed in the previous Chapter. One of the observations from this is that Physics may be more attractive to girls if the content of Physics lessons reflects the interests of girls. This seems to be very important especially at the early stages of secondary school where the "erosion" of girls' attitudes towards science has been clearly observed when compared to attitudes held by primary school girls. Sex bias in favour of boys' interests in the content of science lessons has been observed in primary and early secondary school (see Tables 6-1, 6-4).

In this Chapter 7 the results obtained from the analyses of boys' and girls' interests towards Physics topics will be discussed. Pupils from primary P6/P7 level until the end of high school (S5/S6) are considered.

7.1 Introduction

A general trend found in many studies is that girls are less interested in science (Physics particularly) than boys (Graig and Ayres, 1988; Weinberg, 1995; Ramsden, 1998). 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 interests 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. If this assumption holds, i.e. if any given population is a mixture of qualitatively different interest types, then the usual procedure of taking means over the whole population is an invalid operation and may yield less clear-cut if not misleading results"*
>
> Haussler *et al.*, 1998

Haussler *et al.* (1998) consider *interest* as an "*enduring preference of the individual personality for a particular field of knowledge or action*", and as a three-dimensional construct:

1) interest in a particular subject-matter or topic;
2) interest in a particular context in which the topic is presented;
3) interest in the particular activity engaged (in conjunction with that topic and context).

Using this model they have demonstrated that " *there are no differences between boys and girls [interests in Physics] as far as the interest types as such are concerned*". This means that boys show greater interest than girls in Physics topics related to technical objects and the way they function, as well as in Physics as in a "scientific enterprise" (Physics for the sake of Physics), while girls were found to show greater interest than boys in Physics in the context of its impact on society. Almost no differences have been found in the interests of boys and girls in Physics topics related to explanations of natural phenomena and understanding how Physics can serve humankind.

In this work, boys' and girls ' patterns of interest towards different Physics topics from different contexts and activities have been investigated. Boys' and girls' interests have been compared across different ages, starting from the Primary P6/P7 and up to Secondary S5/S6.

7.2 Regions of boys' and girls' interests in Physics topics

In order to explore the regions of interests of boys and girls towards Physics, several Physics related topics, almost identical for secondary school pupils and slightly simplified for primary school pupils, were offered. Care was taken to consider topics in context and activities which might be attractive both to girls and boys (Johnson and

Murphy, 1984; Smail, 1983; Jorg and Wubbels, 1987; Haussler *et al.*, 1998). The topics selected were chosen to be unrelated to the school syllabus and without any prior analyses of pupils' knowledge of science and their interests in it (example of the topics can be found in Appendix E, pp. 1-5). Pupils were simply asked to choose the topic(s), which they found to be interesting (*"Which of the following interest you?"*). There was no stress on any Physics-related context with the topics. Pupils were free to choose as many topics as they liked.

All the topics suggested can be grouped in the following categories:

A category: *Qualitative explanation how things work* (e.g. how a musical instrument works, how does a telescope work);

B category: *Explanations of how technical objects function* (e.g. how to understand the way electrical equipment works, how to construct a simple device [to measure the level of radiation], how to increase the power of car engine);

C category: *Explaining a natural phenomenon* (e.g. why do we usually have a rainbow after the rain, which atmospheric factors influence the weather on the planet, why do we have earthquakes);

D category: *Medical applications* (e.g. why the use of X-rays can be harmful for the human body);

E category: *Social impact* (e.g. how to solve the world food problem).

F category: *Personal benefit from knowledge* (e.g. how can I earn money by applying my knowledge).

(Example of the suggested topics can be seen from the Appendix A: questionnaire Secondary S2, question 9; questionnaire Secondary S3, question 9, questionnaire Secondary S4 (1998/99), question 11, questionnaire Secondary S5, question 11).

Comparisons were made between boys' and girls' interests, and between age groups. The chi-square statistic (χ^2) was employed to test for significance.

The Tables 7-1, 7-2 below show the general picture of interests obtained separately for girls and boys across various stages. For clarity, the cases where statistically significant differences exist between boys and girls of each particular age, in favour of the gender represented in the Table, are marked by shaded boxes.

Table 7-1: Picture of girls' interests in Physics topics at various ages (%).

(Shaded boxes show where girls' interests are significantly higher than boys)

	Topics suggested	**P6/P7 N=68**	**S2 N=194**	**S3 N=34**	**S4 N=55**	**S5/S6 N=28**
1	how musical instrument works	54	34	21	25	39
2	why we usually have a rainbow after the rain	37	57	55	45	68
3	is it safe to use nuclear power for producing electricity	26	25	36	18	36
4	how can we increase the power of the car engine	-	22	17	7	25
5	how does the telescope work	-	28	28	25	25
6	which atmospheric factors influence the weather on the planet *	63	26	50	36	36
7	why use of X-rays can be harmful for the human body	50	57	60	42	54
8	why do we have earthquakes	71	55	83	35	57
9	how to construct a simple device to measure the level of radiation **	28	15	15	18	14
10	how to solve the world food problem	53	58	42	36	46
11	how can I earn money by applying my knowledge	-	58	62	35	43
12	how to understand the way electrical equipment works ***	50	36	50	18	14
13	what is a black hole in astronomy	-	-	-	47	75

Note 1: the star(s) above some topics in the Tables 7-1, 7-2 means modifications of topics for P6/P7 pupils, namely:

* why the weather is changing all the time (P6/P7)
** how to construct a simple hair dryer (P6/P7)
*** how does a TV remote control work (P6/P7)

Table 7-2: Picture of boys' interests in Physics topics at various stages (%).
(shaded boxes show where boys' interests are significantly higher than girls)

	Topics suggested	P6/P7 N=74	S2 N=189	S3 N=69	S4 N=57	S5/S6 N=68
1	How musical instrument works	31	26	26	21	22
2	Why we usually have a rainbow after the rain	15	42	22	30	32
3	is it safe to use nuclear power for producing electricity	51	48	52	33	46
4	How can we increase the power of the car engine	-	69	50	72	56
5	How does the telescope work	-	33	38	23	22
6	Which atmospheric factors influence the weather on the planet *	38	30	33	30	26
7	Why use of X-rays can be harmful for the human body	47	55	39	28	26
8	Why do we have earthquakes	66	53	60	53	40
9	How to construct a simple device to measure the level of radiation **	35	45	42	30	29
10	How to solve the world food problem	50	38	25	32	29
11	How can I earn money by applying my knowledge	-	70	80	84	75
12	How to understand the way electrical equipment works ***	68	67	63	46	38
13	What is a black hole in astronomy	-	-	-	61	69

Note 1: the star(s) above some topics in the Tables 7-1, 7-2 means modifications of topics for P6/P7 pupils, namely:

* why the weather is changing all the time (P6/P7)
** how to construct a simple hair dryer (P6/P7)
*** how does a TV remote control work (P6/P7)

It can be clearly seen that there are some differences in boys' and girls' interests in Physics topics and these differences are clearly marked through the years of schooling. Girls showed preferences for topics like

- why we usually have a rainbow after the rain (C category)
- why use of X-rays can be harmful for the human body (D category)

while boys were very different from girls in the following topics:

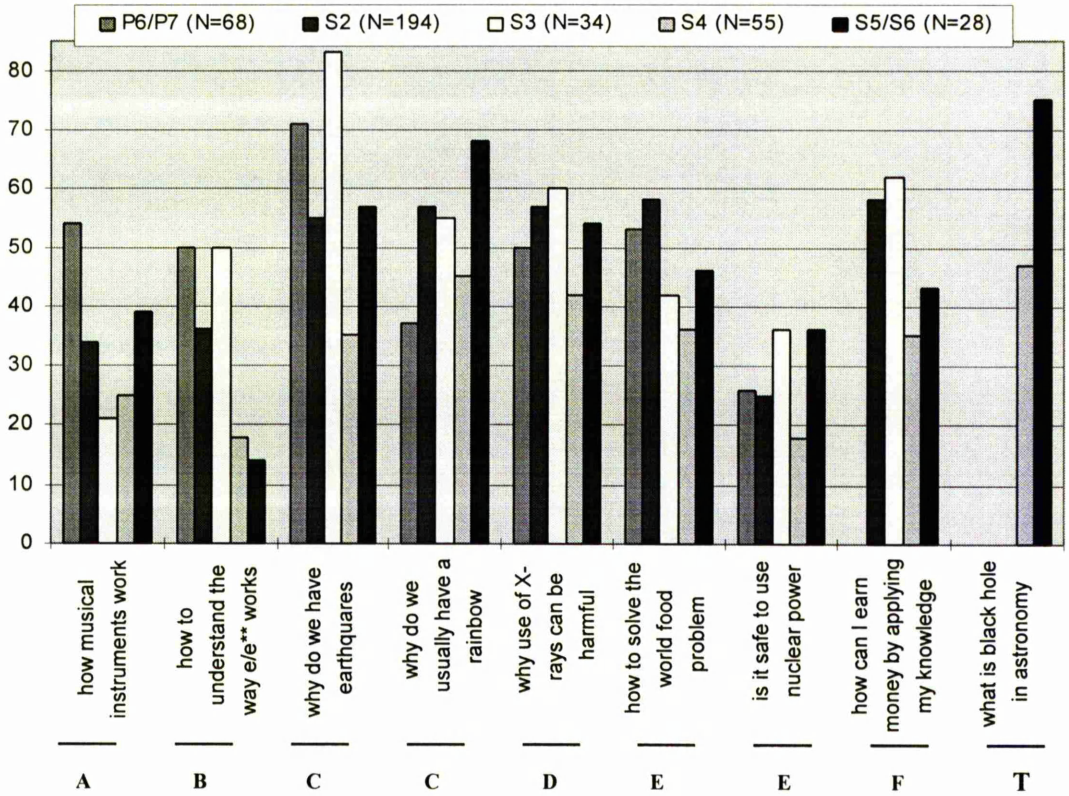
- how can we increase the power of the car engine (B category)
- how to understand the way electrical equipment work (B category)
- how to construct a simple device to measure the level of radiation (B category)
- how can I earn money by applying my knowledge (F category).

Apart from the "technical topics" (B category) boys' interests towards "*how can I earn money by applying my knowledge*" were found to be the highest and very strong throughout the years of schooling. Girls' interests towards the last topic were also high although significantly lower than boys (see Table 7-1, 7-2). This tendency can be expected and explained if differences in gender psychology are taken in to account. Boys are normally brought up as future "bread winners" and it is expected that they will use their knowledge in the best possible way to succeed. Expectations from girls are different, and it was observed that interests in earning money through applying knowledge is less interesting for them than interest in understanding *"why do we have earthquakes"* (see Table 7-1). Altruistic reasons for choosing a science-related major were predominantly expressed by 91 per cent of women in research conducted in the USA. It has been observed that *"women are more likely than men to rank materialistic goals below the desire to work at something they care about, either as a matter of personal fulfilment, or in pursuit of a valued social cause"* (Seymour and Hewitt, 1997, p. 69). The altruistic character of girls' interests in Physics was also stressed in the work of Stewart (1998). That is why it is more likely to expect that girls will learn Physics mainly because it is interesting for them. This statement can be supported by the data obtained from the university Physics students, where it was found that one of the main reasons for taking Physics at university was interest in the subject (see Appendix O, p. 1). Another finding of the present research supports the altruistic reasons for females to study Physics: these findings are about students' perceptions of the profession of Physicist. For the level 1 females and males, being a Physicist is likely to be interesting, although at the same time, difficult. Materialistic advantages of this profession were rated rather low by both females and males university Physics students. [Pupils doing Physics course at school were more positive about it. However the strongest perception of secondary school pupils is that "being a Physicist is hard" (see Appendix I, p. 3-7)}.

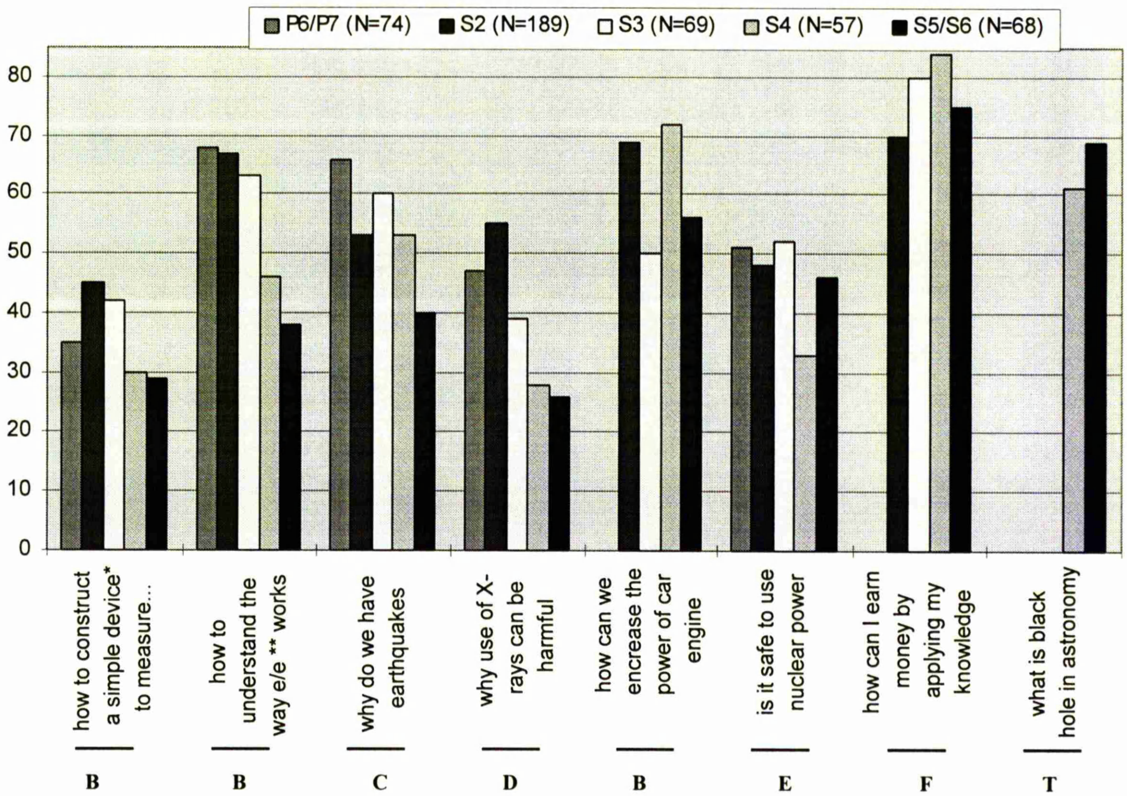
Apart from topics traditionally attractive to boys or girls, there were topics where interests of boys and girls were equally high: "which atmospheric factors influence the weather on the planet" ("why the weather is changing all the time" for P6/P7 pupils), "how does a telescope work", "why the use of X-rays can be harmful for the human body". (The data regarding these analyses are in the Appendix E, pp. 1-5).

In the next step, the topics valued highly by boys and girls will be discussed. As it is expected topics valued highly by boys and girls were different to some extent. On the Graphs 7-1, 7-2 the distribution of frequencies are shown for topics which attracted more than 30 per cent of boys/girls interest at any age group

Graph 7-1: Topics of girls' interest in Physics



Graph 7-2: Topics of boys' interests in Physics



*how to construct a simple hair dryer (for P6/P7);

**how does a TV remote control work (for P6/P7)

It can be seen from the Graph 7-1 and Graph 7-2 that the main interests of girls lie in the topics from categories

- C - "explaining natural phenomenon",
- D - "medical applications",
- E - "social impact",
- F - "personal benefits",
- A - "qualitative explanation how things work",

while interests of boys mainly lie in the topics from categories

- B - "explanation of technical objects function", and also in the topics from categories as above
- C, D, E, and F.

(categories are marked on the Graphs 7-1, 7-2).

Both girls and boys from S4 and S5 levels demonstrated high interest in topic related to astronomy (marked as T category on the Graphs 7-1, 7-2). This topic was offered only to S4 and S5/S6 pupils.

It can be clearly seen that topics from the categories C, D, E and F were interesting both to boys and to girls, while topics from the category B (explanation of technical objects function) were much more attractive to boys than to girls.

Haussler (1998) *et al.* came to the conclusion in their work that "*there are no differences between boys' and girls' [interests in Physics] as far as the interests' types as such are concerned*". It was interesting to check that with Scottish pupils. To find out who demonstrated more interests towards the topics suggested (boys or girls) it was decided to compare the total number of responses (frequency) given by boys and girls on the suggested topics at various stages. These obtained frequencies (Freq.) of boys' and girls' responses were compared using the method of chi-square. The comparison was performed relatively to the "maximum possible frequency" (Max) for every gender and for every age group. "Maximum possible frequency" is equal to [number of topics suggested] multiplied by [number of pupils in the age group], i.e. the number obtained if all pupils in the age group selected all topics suggested. The results of the analysis are given in the Table 7-3.

Table 7-3: Differences of boys' and girls' interest in Physics topics

	Girls			*Boys*					
Age group	**No.**	**Freq.**	**Max**	**No.**	**Freq.**	**Max**	χ^2	**significance**	**favoured**
P6/P7	68	294	612	74	297	666	1.52	ns	
S2	194	914	2328	189	1089	2268	35.77	<0.1%	Boys
S3	34	183	408	69	370	828	0.00	ns	
S4	55	222	715	57	310	741	18.09	<0.1%	Boys
S5/S6	28	149	364	68	347	884	0.31	ns	

note: df=1 for every case considered

Following the data given in the Table 7-3 it can be seen that in primary P6/P7, Secondary 3 and Secondary 5/6, there are no differences between the total numbers of choices of girls and boys. At these stages, the topics suggested look like being interesting both to girls as well as to boys. This result is also interesting because there were some topics where girls' interests are normally significantly lower than boys, nevertheless, in general no difference were found in boys' and girls' total number of topics chosen at P6/P7, S3 and S5/S6 levels. However, in Secondary 2 and Secondary 4, boys demonstrated significantly higher interest towards the suggested topics than girls (significance is less than 0.1%!). These two stages of schooling (S2 and S4) are decision-making stages when pupils make their choice about the subjects for a future study: i.e. about Standard Grade courses at S2 level and about Higher Grade courses at S4 level. Two things were observed to happen simultaneously:

1) large drop in girls' interests at S2 and S4 stages;

2) decision making about further study at S2 and S4 stages.

It is possible that decision making connects in some way to the decline of girls' interests in Physics (see Table 7-3). The questions can be asked:

- *Why is this decline taking place only for girls?*

It is a suggestion that "selection" may start playing such a significant role in shaping girls' interests. S3 girls are "qualitatively" different from and a more selected group than S2 girls, as well as S5/S6 girls are more selected group with respect to S4. If it is a selection effect,

- *Why it does not affect boys' interests in the same way?*

It is possible that the self-selection process in Physics is different for girls and boys. The possible explanation of this difference can be in social stereotypes of boys and girls that are known to be different. According to these stereotypes Physics is "traditionally" considered as a masculine field of activity, and girls, when it comes to the decision making point often follow the accepted stereotypes and, to be consistent with themselves, either leave Physics or demonstrate lower interests in Physics. [Balance Theory (see Chapter 1, p.12) can be used as a tool to describe these changes in girls' interests using the language of psychologists: stereotypes may cause an erosion of girls' attitudes towards Physics as a subject for further study. This erosion will cause some doubts and feelings of discomfort. To have a previously existing cognitive system in balance and harmony again, some girls will follow traditionally accepted stereotypes and will not take Physics for further study (e.g. for Standard Grade), while some girls will overcome the stereotypes and stay with Physics. However, coming back to the state of equilibrium and balance in the previously existing system of cognition, those girls who stayed with Physics demonstrate shaping of their interests in Physics around "traditionally" acceptable fields of interests for girls]. It was observed that girls who stayed with Physics overcame the stereotypes, but tended to be different from the rest of girls (Gardner, 1975; Smithers and Collings, 1981).

In the next sub-chapter an attempt will be made to trace the changes in interests of girls and boys as they more from one level to another.

7.3 "Erosion" of girls' interests in Physics topics at S2 level

The marked decline in attitudes of S2 pupils towards their science lessons in comparison to primary P6/P7 pupils' attitudes has been observed in this study (see section 6.3.2, pp.82-83). Within the S2 group, girls showed significantly less positive attitudes towards science lessons than boys. The data in the Table 7-3 show that S2 girls' interests towards Physics topics were significantly lower than interests of S2 boys towards the same topics. At primary P6/P7 both girls and boys demonstrated similar level of interest towards topics suggested.

A comparison has been done between P6/P7 and S2 girls' interests and between S2 and S3 girls' interests towards the same Physics topics (the same comparison has been done for boys). A comparison of S2 and S3 pupils can be criticised (as well as comparison of S4 and S5/S6 pupils) because these groups are qualitatively different. However, the general picture obtained shows interesting patterns, very different for girls and boys in their transition from one level to another.

In the Tables 7-4, 7-5 below the results of comparison (P6/P7)/S2 and S2/S3 girls' interests are shown. These data for girls need to be compared to those one obtained for boys, which is shown in the Tables 7-6, 7-7.

Table 7-4: Comparison of girls' P6/P7 and S2 interests in Physics topics (%)

(Shaded boxes show where girl's interests are significantly higher than boys)

topics suggested	**P6/P7 Girls (N=68) %**	**S2 Girls (N=194) %**	χ^2 df=1	**significance**	**favoured**
how musical instrument works	54	34	8.4	1%	P6/P7
why we usually have a rainbow after the rain	37	57	8.07	1%	S2
is it safe to use nuclear power for producing electricity	26	25	0.03	ns	-
why use of X-rays can be harmful for the human body	50	57	1.00	ns	-
why do we have earthquakes	71	55	5.34	5%	P6/P7
how to construct the simple device to measure the level of radiation *	28	15	5.67	5%	P6/P7
how to solve the world food problem	53	58	0.51	ns	-
how to understand the way electrical equipment work **	50	36	4.13	5%	P6/P7

Note: * how to construct a simple hair dryer (for P6/P7)
** how does a TV remote control work (for P6/P7)

Table 7-5: Comparison of girls' S2 and S3 interests in Physics topics (%)
(Shaded boxes show where girl's interests are higher than boys)

topics suggested	S2 N=194	S3 N=34	χ^2 df=1	significance %	favoured
how musical instrument works	34	21	2.25	ns	-
why we usually have a rainbow after the rain	57	55	0.05	ns	-
is it safe to use nuclear power for producing electricity	25	56	13.45	1%	S3
how can we increase the power of the car engine	22	17	0.43	ns	-
how does the telescope work	28	28	0	-	-
which atmospheric factors influence the weather on the planet	26	50	8.00	1%	S3
why use of X-rays can be harmful for the human body	57	60	0.1	ns	-
why do we have earthquakes	55	83	9.39	1%	S3
how to construct the simple device to measure the level of radiation	15	15	0	-	-
how to solve the world food problem	58	42	3.00	ns	-
how can I earn money by applying my knowledge	58	62	0.19	ns	-
how to understand the way electrical equipment work	36	50	2.4	ns	-
what is black hole in astronomy	-	-	-	-	-

It can be clearly seen that S2 girls' interests towards Physics topics were often lower than interests of younger girls in Primary school and interests of girls from the more selected S3 group. Nothing like this occurs with boys. Secondary S2 boys demonstrated almost the same interests towards topics suggested as Primary P6/P7 boys and even significantly higher interests than more selected S3 boys. Only in F category (personal benefits from the knowledge) boys from the S3 group were showing more interest than S2 boys. The Tables 7-6, 7-7 below provides the data for boys.

Table 7-6: Comparison of boys' P6/P7 and S2 interest in Physics topics (%)
(Shaded boxes show where girl's interests are higher than boys interests)

topics suggested	P6/P7 Boys (N=74) %	S2 Boys (N=189) %	χ^2 df=1	significance %	favoured
how musical instrument works	31	26	0.66	ns	-
why we usually have a rainbow after the rain	15	42	17.04	1%	S2
is it safe to use nuclear power for producing electricity	51	48	0.19	ns	-
why use of X-rays can be harmful for the human body	47	55	1.35	ns	-
why do we have earthquakes	66	53	3.62	ns	-
how to construct the simple device to measure the level of radiation *	35	45	2.16	ns	-
how to solve the world food problem	50	38	3.12	ns	-
how do understand the way electrical equipment work **	68	67	0.02	ns	-

* how to construct a simple hair dryer (for P6/P7)
** how does a TV remote control work (for P6/P7)

Table 7-7: Comparison of boys'S2 and S3 interest in Physics topics (%)

(Shaded boxes show where boys' interests are higher than girls' interests)

topics suggested	S2 N=189 %	S3 N=69 %	χ^2 df=1	significance %	favoured
how musical instrument works	26	26	0	ns	-
why we usually have a rainbow after the rain	42	22	8.71	1%	S2
is it safe to use nuclear power for producing electricity	48	52	0.32	ns	-
how can we increase the power of the car engine	69	50	7.91	1%	S2
how does the telescope work	33	38	0.56	ns	-
which atmospheric factors influence the weather on the planet	30	33	0.21	ns	-
why use of X-rays can be harmful for the human body	55	39	5.18	5%	S2
why do we have earthquakes	53	60	1.00	ns	-
how to construct the simple device to measure the level of radiation	45	42	0.19	ns	-
how to solve the world food problem	38	25	3.78	ns	-
how can I earn money by applying my knowledge	70	80	6.78	1%	S3
how do understand the way electrical equipment work	67	63	0.36	ns	-
what is black hole in astronomy	-	-	-	-	-

It looks like curiosity and interests in Physics topics is the highest for boys at S2 stage in comparison to interests of boys from the stages P6/P7 and S3, while interests of girls are the lowest at S2 stage.

To try to complete the picture, it was decided to add two more Tables to investigate the differences between primary pupils' interests in Physics topics and interests of more selected S3 group who were going to sit Physics for Standard Grade exams. Two Tables 7-8, 7-9 show the data separately for boys and girls.

Table 7-8: Comparison of girls' P6/P7 and S3 interests in Physics topics (%)

topics suggested	**P6/P7 Girls, (N=68) %**	**S3 Girls, (N=34) %**	χ^2 df=1	**significance %**	**favoured**
how musical instrument works	54	21	10.07	1%	P6/P7
why we usually have a rainbow after the rain	37	55	3.00	ns	-
is it safe to use nuclear power for producing electricity	26	36	1.09	ns	-
why use of X-rays can be harmful for the human body	50	60	0.91	ns	-
why do we have earthquakes	71	83	1.74	ns	-
how to construct the simple device to measure the level of radiation *	28	15	2.12	ns	-
how to solve the world food problem	53	42	2.00	ns	-
how do understand the way electrical equipment work **	50	50	0	ns	-

Table 7-9: Comparison of boys' P6/P7 and S3 interests in Physics topics (%)

topics suggested	**P6/P7 Boys, (N=74) %**	**S3 Boys, (N=69) %**	χ^2 df=1	**significance %**	**favoured**
how musical instrument works	31	26	0.44	ns	-
why we usually have a rainbow after the rain	15	22	1.17	ns	-
is it safe to use nuclear power for producing electricity	51	52	0.02	ns	-
why use of X-rays can be harmful for the human body	47	39	0.93	ns	-
why do we have earthquakes	66	60	0.55	ns	-
how to construct the simple device to measure the level of radiation *	35	42	0.74	ns	-
how to solve the world food problem	50	25	9.48	1%	P6/P7
how do understand the way electrical equipment work **	68	63	0.40	ns	-

Note: for both Tables 7-8, 7-9:
* how to construct a simple hair dryer (for P6/P7)
** how does a TV remote control work (for P6/P7)

The results from the last two Tables 7-8 and 7-9 show that interests in Physics topics of primary pupils and of S3 pupils (self-selected towards Physics group) were almost the same! Both girls and boys in primary school are interested in Physics topics to the same extent as those boys and girls who have chosen to study the subject at S3 level and who, as expected, have more interest in the subject than the rest of the pupils in their age-group. Following the data obtained, it looks as if, at the approach to secondary school there were almost no differences in girls' and boys' interests in Physics and these interests were strong for both genders. The obvious separation in interests towards Physics topics between boys and girls starts from early secondary schooling. At this stage it may be that social stereotypes of genders start playing a significant role and cause a separation between boys and girls in their interests and further fields of activity.

Further comparison was performed between Standard Grade and Higher Grade boys/girls. Nothing interesting was found and that is why further discussion is omitted. The data are in the Appendix E, pp. 8-11.

7.3.1 Discussion

No differences in interests of boys and girls towards the Physics topics suggested have been observed in late Primary, Secondary S3 and S5/S6 stages. This evidence confirms the results obtained by Haussler *et al.* (1998) and statements like "*boys have greater interests in Physics than girls do*" (Clarke, 1972; Weinberg, 1995; Ramsden, 1998, Graig and Ayres, 1988) can be questioned. However, at some stages of schooling (and these stages were found to be the decision making ones), girls' interests towards Physics topics show a significant decline relative to boys' interests. The supposition was made that the rather negative impact of social stereotypes on girls' interests towards Physics, which consider Physics as a traditionally male-dominated field of activity, caused this. In this context, the Initiative of the Institute of Physics about "*promoting to pupils in their early mid-teens, in a light and colourful way, an awareness of the occupational areas in which those who have studied physics are employed*" can be highly praised. "*What nearly always surprises young people when they look into career opportunities with Physics, is the number and range of openings that exist. Moreover, few carry the term 'physicist' in their title*" (Wilson, 2000). This looks particularly important for girls, many of whom may miss out career opportunities that studying of Physics can bring simply because of strong social stereotypes and lack of confidence about the opportunities which a knowledge of Physics opens to them.

The Theory of Planned Behaviour (see Chapter 3) is a tool explaining people behaviour (intention to behave) through the combination of three factors:

- attitude towards a behaviour,
- subjective norm component,
- perceived behavioural control.

On this basis, it can be shown which of the components play a dominant role in the decision making process with school children. The following picture has been obtained:

■ *Primary P6/P7 stage:*

1) attitudes towards science lessons were found to be very positive among girls and boys;
2) there is no need to make a choice of subjects at secondary school (stereotypes can be ignored);
3) interests of boys and girls towards the suggested Physics topics were similar, and
4) percentage of intentions towards studying science at secondary school was almost equal and very high both among girls and boys.

■ *Secondary S2 level:*

1) boys' attitudes towards science lessons were significantly more positive than girls;
2) it is a decision making stage and social stereotypes say that Physics is not for girls;
3) significant decline of girls' interests towards the suggested Physics topics relatively to boys' interests was observed, and
4) twice as many boys than girls would like to study Physics for Standard Grade.

■ *Secondary Standard Grade S3 level*:

1) attitudes of girls towards Physics lessons were as positive as boys;
2) there is no need for decision making and girls can enjoy what they are doing at the moment,
3) intensity of girls' interests in Physics topics is similar to boys;
4) no differences in boys' and girls' intentions towards Higher Grade Physics were observed.

■ *Secondary Standard Grade S4 level:*

1) girls' attitudes towards Physics lessons were very positive and similar to boys;

2) decision making stage, stereotypes start playing role (significantly more S4 boys than girls think that "Physics is definitely 'their' subject" (see Appendix C p. 4), and

3) significant decline of girls' interests in the suggested Physics topics relatively to boys', however

4) no differences in intentions of girls and boys towards Higher Grade Physics.

■ *Secondary Higher Grade Physics S5/S6 level:*

1) girls' attitudes towards Physics lessons were similar to boys;

2) selection process may be considered as completed and stereotypes may not be such important as in the earlier stages;

3) no differences in boys' and girls' interests towards the suggested Physics topics;

4) intentions of girls and boys towards a Higher degree is similar, intentions of girls and boys towards studying Physics at university is similar (see Table 6-22).

Following these observations it can be seen that, even though gender stereotypes play some negative role for girls at S4 stage, the intentions of boys and girls towards the Higher Grade Physics were not different. This may be explained by looking at attitudes of girls and boys towards their Physics lessons at this stage: attitudes of S4 girls and boys were similar and very positive. That is why looking back at S2 stage where the real problem for "girls in Physics" can lie, some evidence-based suggestions can be made to attract more girls to Physics:

1. Importance of syllabus: Science lessons should be appealing to girls, consistent with their interests and previous experience. The content of Physics lessons in the frame of the science lessons should introduce pupils to the idea about a variety of phenomena which Physics covers and describes, (e.g. it was observed that, in one experimental school, girls at the end of the S2 stage had very strong associations of Physics with electronics. The

percentage of girls who decided to take Physics for Standard Grade from that school was significantly lower when compared to girls who were going to do Standard Grade Physics from the other two experimental school, see Appendix G, p. 4). That is why it is very important to avoid gender-related bias in introduction to Physics at the early stages of secondary school. This approach is very important in maintaining girls' positive attitudes towards science subject at secondary school (which were very positive at primary school).

2. Early subject-related career education: Introducing pupils to the variety of possibilities, which a degree in Physics can open to them from early stages of secondary school. This is particularly important for girls to help them to overcome existing gender-related stereotypes about Physics.

7.4 Preferable activities in Science/Physics lessons

Only pupils from secondary school have been asked to answer "what do you enjoy most in your Physics (science) lessons?" The aim of this review was to explore what boys and girls enjoy doing in their Physics lessons, and to see if there are any marked differences between genders in it.

It has been observed that boys doing Standard Grade Physics and Higher Grade Physics were significantly more interested than girls in "studying making equipment". Moreover S4, S5/S6 boys demonstrated, significantly higher than girls, level of enjoyment from "doing practical work on computer". Other differences between boys and girls preferences were not persistent and reflect only variations for given age group (see Appendix F, p. 1-4).

Since the 'erosion' of S2 girls' interests towards the suggested Physics topics has been observed, more detailed analyses of S2 pupils was carried out. This age group appeared to be very different from the rest. S2 pupils' analyses revealed that except "studying making equipment" boys were significantly more interested than girls in:

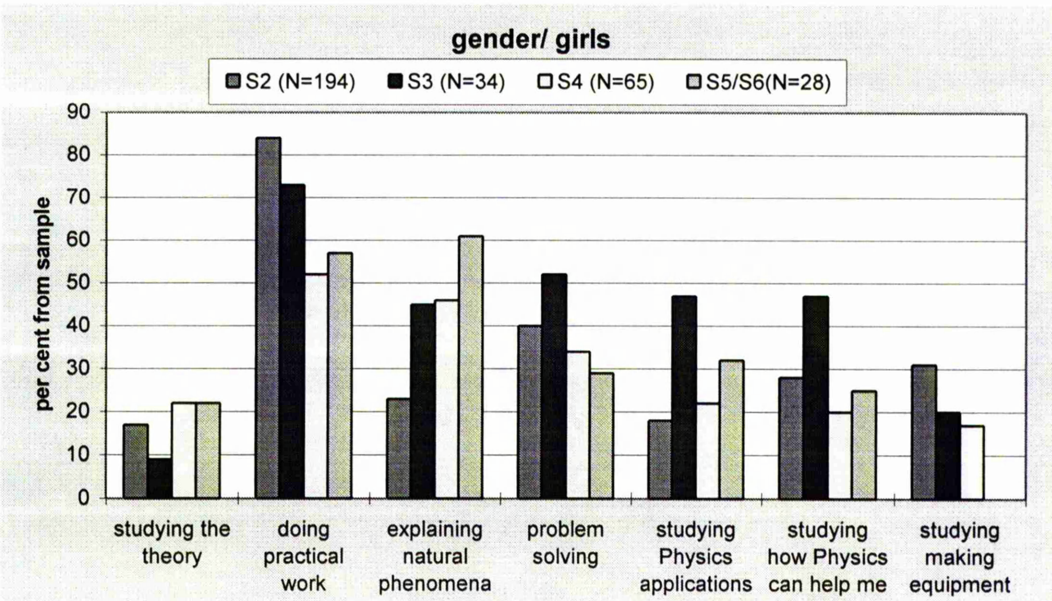
- studying science applications in life,
- studying how science can help in life,

- solving every day problems

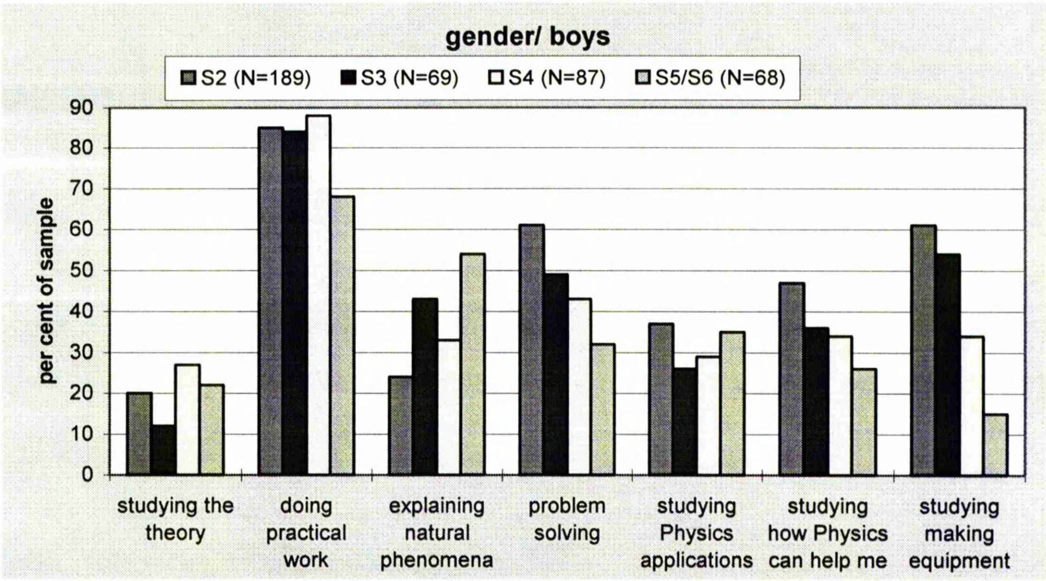
S2 girls enjoy mostly "doing practical work", "solving problems", "studying about human body" and "studying how science can make our lives healthier". Except "problem solving" (where boys were significantly more interested in than girls), boys enjoy these activities as much as girls do.

On the Graphs 7-3, 7-4 below the summary of activities appealing to at least 30 per cent of girls and boys from any age group is shown (frequencies of responses about "studying the theory" are represented as well for comparison purposes).

Graph 7-3: Preferable activities of girls



Graph 7-4: Preferable activities of boys



It can be seen that the most enjoyable activity for both, girls and boys, from all age groups is "*doing practical work*". Only S5/S6 girls value "*explaining natural phenomena*" a little bit, but not significantly, higher than doing practical work.

From the Graphs 7-3, 7-4, it follows that girls' interests in doing practical work decline significantly between S3 and S4 stages (see Appendix F, p. 6). Boys demonstrate quite strong and stable interest and enjoyment from practical work up to S4 level and then a significant decline at S5/S6 stage (see Appendix F, pp. 5-7). A significant decline in boys' enjoyment from "*studying making equipment*" has been observed as boys grow up, (see Appendix F, pp. 5-7). Indeed, both girls and boys continue enjoying "*explaining natural phenomena*" through the years of their secondary schooling.

"*Studying the theory*" has been found the least attractive activity in Science/Physics lessons, especially for S2 girls and boys.

7.5 Summary

1. Boys demonstrated levels of interests significantly higher than girls did in topics related to technical objects and the way they function. Girls preferred topics related to social, medical applications of Physics. Both girls and boys demonstrated high level of interest in topics related to explaining natural phenomenon, practical benefit from knowledge.

2. It has been observed that girls' and boys' interests in the suggested Physics topics were not different at P6/P7, S3 and S5/S6 levels. At S2 and S4 levels, a significant decline of girls' interests in Physics topics relative to boys was observed. Two processes were found to happen simultaneously for girls: falling of girls' interests towards Physics at S2 and S4 stages and decision making about further study at these stages. Nothing like this was observed for boys.

3. Interests of Primary school girls and boys in the suggested Physics topics were found to be not different and similar to interests of S3 pupils. The obvious erosion of girls' interests in Physics topics was observed at S2 level.

4. Practical work was found to be the most enjoyable activity in Science/Physics lessons for both girls and boys at every stage of schooling. This is especially true for younger children, and it was observed that interest in practical work declines as pupils grow older. Indeed, doing practical work on a computer looks like appealing more to boys than to girls. Studying the theory was found to be the least enjoyable activity at school for all pupils from every age group, especially for S2 pupils.

Chapter 8

Physics students at Glasgow University

About 80 percent of S5/S6 Higher Grade Physics pupils who participated in the present research study expressed the intentions to go to university after school (see Chapter 6, p.98). This picture is consistent with that of published by the National Committee of Inquiry into Higher Education, 1998. About 11 percent of those pupils were thinking about studying Physics at university (see Table 6-22).

The next three Chapters of this thesis will be devoted to a consideration of university Physics students. Chapter 8 provides a general survey of students studying Physics at the University of Glasgow. This includes an analysis of students' entry qualifications in Higher Physics and Higher Mathematics, an analysis of factors, which brought students to the Physics department, students' expectations from the Physics department and the degree to which these expectations were met by the department. Chapter 9 looks at students' attitudes towards the university Physics course and students' perceptions of self in the Physics course. Chapter 10 attempts to find out the factors which may influence students away from Physics after a year of university experience in it.

Discussion of the "girls' issue in Physics" will be continued. The data in the next two Chapters will be considered separately for males and females.

8.1 Introduction

Every year a large number of able and motivated students enter the Physics Department of the University of Glasgow with the intention of doing an Honours Physics course (data obtained from students records). However, about 20 percent of these students leave Physics after their first year of university experience. The first year university Physics course seem to be too challenging for some students and the reasons for this are worth exploring.

To begin with, it was important to consider the "quality" of students planning a degree in Physics. What are their abilities in Physics and Mathematics? What kind of experience in Physics did they have at school? What kind of factors influenced their decisions to study Physics at university level? What did they expect from the university Physics course? This information is necessary to build a picture of the factors that influenced students to come to the Physics department. This information may be helpful, as well, in understanding the reasons for some students to leave Physics a year later.

It was decided to take a group of the first year students studying in the Physics Department of the University of Glasgow, the largest University in Scotland, and work with these students to find out what kind of factors can influence their behaviour to study or not to study Physics for an Honours Degree. The level 2 Physics students were also surveyed to maintain the comparison analyses between Physics level 1 and Physics level 2 university courses.

Since the current research was carried out in the frame of a Scottish university, some words need to be said about the Scottish Higher Education System, which is different from that operating elsewhere in the UK.

8.2 Scottish Higher Educational System

> *"All my life as an academic I have been conscious of a quite special debt to Scottish intellectual influences and a quite special admiration for the Scottish university tradition, both for its achievements and for the educational principles on which it rests'*
>
> *Lord Robbins, 1968*

Higher education in Scotland forms a part of an educational tradition which has always been, and which continues to be, highly distinct from the rest of the United Kingdom. The basis for entry to higher education in Scotland is the results gained at the Higher Grade examinations. As it has been pointed in the Chapter 6 (where the structure of the Scottish School education system was considered), students can normally choose up to five "Highers" in the Fifth Year (S5) of secondary school. As has already been shown above currently about 80 percent of Scottish school students stay for S5 or undertake equivalent study at a further education college (National Committee of Inquiry into Higher Education, 1998).

Another significant difference for entry to higher education in Scotland is that students' entry is usually to a faculty while for the rest of the UK the entry is usually to a department. Students in Scotland can choose normally up to three subjects to study in the university during the first year. The selection for a specific Honours course is often made at the end of the second year. Such a system provides students with great flexibility and choice. It is a very common situation in Scotland for students, to change their Honours subject(s) during their early university years. At the University of Aberdeen, for example, 60 percent of the students on undergraduate MA and BSc programmes graduate with degrees which are different from those declared as intended entry (National Committee of Inquiry into Higher Education, 1997). To obtain a Degree in Scotland, students have to study for four years, while only three years are required in England and Wales.

8.3 Methodology of collecting the data

In order to build up a picture of students coming to the University of Glasgow Physics Department the following approaches were adopted:

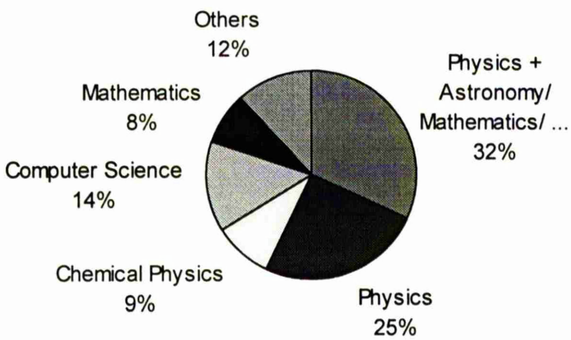
1. Full analyses of 1997/98 level 1 students' records, including:
   a) entry qualifications in Physics and Mathematics;
   b) previous experience in Physics;
   c) proposed degree subject(s);
   d) courses taken at level 1;

2. Questionnaires for the level 1 and the level 2 students to gather information about:
   a) reasons for studying Physics;
   b) reasons for choosing this particular university;
   c) attitudes towards Physics at school;
   d) students' expectations from and their fulfilment in the university Physics course.

8.4 Proposed Honours subjects of level 1 Physics students

The total number of students who entered the Physics Department of the University of Glasgow in the 1997/98 academic year was 202 (42 girls and 160 boys). From students' records, the data about distribution of all these students according their proposed degree subject(s) were obtained. This distribution is represented on the Diagram 8-1 below:

Diagram 8-1: Distribution of the proposed degree subjects for 1997/98 level 1 students



As can be seen from the Diagram 8-1, a total of 66% of the level 1 students were planning to do Physics for a degree - 25% of them were planning a single Honours Physics and 41% were going to do a combined Honours Physics.

Since particular attention in this research was devoted to the problems of sex imbalance in Physics, all the data collected were considered separately for male and female students. Considering 1997/98 level 1 students planning a degree in Physics, the following distribution according gender was observed:

32 (16%) girls

132 (66%)

100 (50%) boys

(percentages are of the total 1997/98 level 1 year group)

The ratio of males to females in the level 1 course was about 4 (160/42), while for the group of students planning to take Physics for a degree it was about 3 (100/32).

Table 8-1: Distribution of females and males planning to take Honours Physics.

Physics for a Degree
132 (66%)

	Physics		Physics + Astronomy/ Math/...		Chemical Physics	
	females	*males*	*females*	*males*	*females*	*males*
Number, N	10	40	17	47	5	13
Percentage	5%	20%	9%	24%	3%	7%
male/female ratio	4		2.8		2.6	

(percentages are of the total 1997/98 level 1 year group)

It can be seen from the Table 8.1, that the ratio of males to females was higher for a single Honours Physics, which means that more girls were planning to study for a combined Honours Physics than for a single Honours Physics.

A year later, in 1998/99 academic year, the records of the 98/99 level 2 Physics students were analysed. It was found that only 43% (N=85) out of the 66% (N=132) 1997/98 level 1 Physics students, who had intended to take Physics for Honours at the beginning of their university Physics course, entered the 98/99 level 2 Physics course (percentages are of the total 1997/98 level 1 students). In fact, 23% (N=47) of the 1997/98 level 1 students planning to take Physics for a degree after school changed their mind about Honours Physics during the first year of their university Physics course.

The Table 8-2 below shows the approximate number of potential Physicists being lost in the transition from the level 1 to level 2 Physics course for the three year period.

Table 8-2: Numbers of potential Physicists left Physics after level 1 (over 3 year time)

Year of study	Number of students entering level 1 Physics course	Number of students planning a degree in Physics	Number of students entering level 2 Physics course	Number of potential physicists who left Physics after level 1
96/97	143 100%	93 65%	63 44%	30 21%
97/98	202 100%	132 66%	96 48%	36 18%
98/99	148 100%	93 63%	70 44%	21 19%

Real situation: in transition from level 1 to level 2 the drop in the number of students originally planning to take Physics for a degree is about 20%.

8.5 Entry qualifications of the 1997/98 level 1 Physics students

Attitudes towards Physics and achievements in Physics were found to be correlated (Weinberg,1995). Achievement is usually associated with a positive stimulus and can form positive beliefs about the subject, while positive attitudes stimulate and motivate to study which can be reflected in good achievement.

Students' entry qualifications in Physics and Mathematics were analysed and the data of this analysis are shown in the Table 8-3 below. It has to be noted that the majority of students doing 1997/98 Physics course came from Scottish schools (89%). That is why the distribution in the Table 8-3 is represented in terms of Higher Physics and Higher Mathematics. "Others" represents the degree results of students who obtained English or European qualifications in Physics and Mathematics.

Table 8-3: Entry qualifications of the 1997/98 level 1 Physics students in Physics and Mathematics (%).

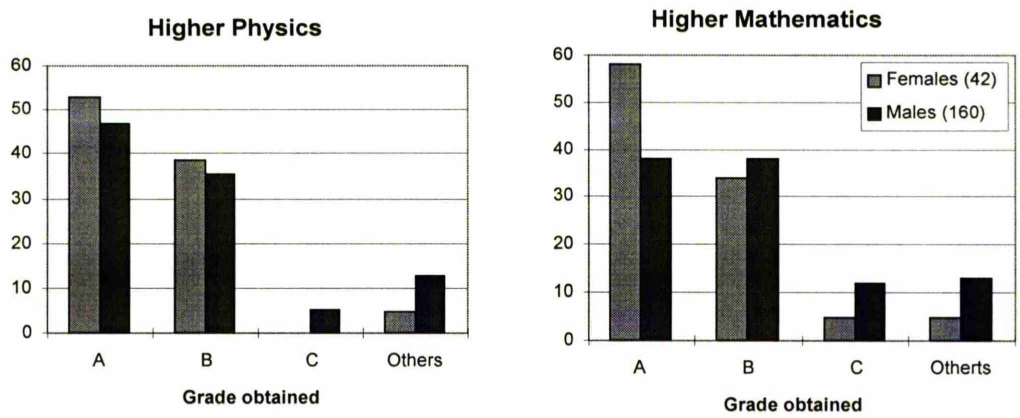
Grade	A		B		C		"Others"	
subject/entry qualification	**Higher Physics**	**Higher Maths.**	**Higher Physics**	**Higher Maths.**	**Higher Physics**	**Higher Maths.**	**Physics**	**Maths.**
Males, % (N=160)	37	30	28	30	4	9	10	10
Females, % (N=42)	11	12	8	8	0	1	1	1
Total, % (N=202)	48	42	36	38	4	10	11	11

It can be seen from the Table 8-3 that the "quality" of students doing 1997/98 level 1 Physics course was very high:

- 84% of the students had "A" or "B" in Higher Physics and
- 80% had "A" or "B" in Higher Mathematics.

Grades in Higher Physics and Higher Mathematics separately for females and males doing 1997/98 level 1 Physics course are shown on the Graph 8-1 below:

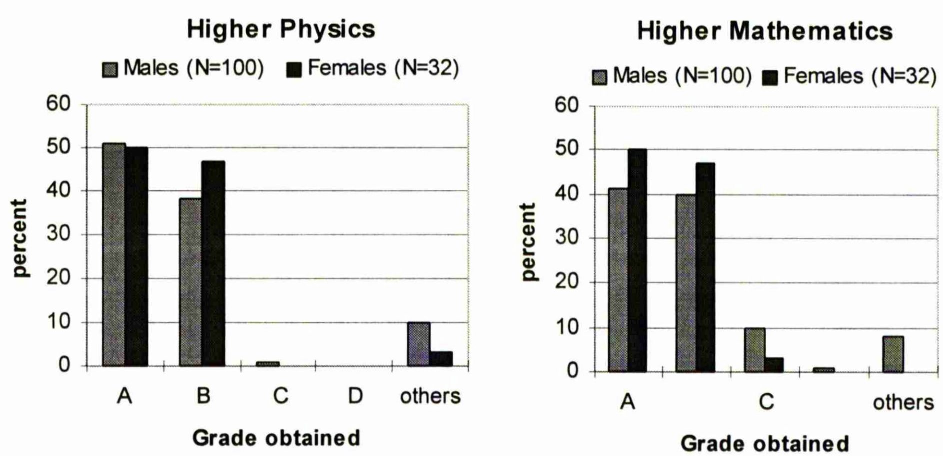
Graph 8-1: Entry qualifications of the level 1 females and males in Physics and Mathematics, % (1997/98)



Analyses using chi-square statistics revealed that no differences were found between females' and males' entry grades in Higher Physics but, females' grades in Higher Mathematics were found to be statistically higher than grades of male students (χ^2=5.45 is significant at 0.05 level of probability when df=1).

Entry grades in Physics and Mathematics of males and females planning a degree in Physics were found to be similar. The Graph 8-2 below shows the data separately for females and males.

Graph 8-2: Entry qualifications of the 1997/98 level 1 females and males planning a degree in Physics.



It can be seen from the Graph 8-2 that entry qualifications in Physics and Mathematics of students planning to take Physics for a degree were very high: one in two females had "A" in Higher Physics and Higher Mathematics, one in two males had "A" in Higher Physics. This picture is consistent with the Institute of Physics observation: *"in the UK, students starting physics degrees have much better qualifications than those studying other science and engineering subjects, with the exception of medicine."* (Physics World, 99; 10, p. 3).

8.6. Variations of students' intentions towards a degree in Physics

8.6.1 Situation at the beginning of the 1997/98 academic year

Students entered the university 1997/98 Physics course were separated into two large groups at the beginning of the academic year:

Group I - those students who were planning to do Honours Physics
Group II - those students who were planning to do a degree in other subject(s).

Table 8-4: Distribution of students according to proposed degree in Physics
(Source: students' entry records)

Situation on entry (October, 1997)		Numbers
Group I (Physics for a degree)	→	132 (66%)
Group II (not Physics for a degree)	→	70 (34%)

(Note: percentages are taken of the total 1997/98 level 1 group)

In order to investigate the factors which may influence students' intentions towards studying or not studying Physics for a degree, a set of the questionnaires was prepared [see Appendix A, questionnaire level 1/level 2 (1997/98)]. Questionnaires were applied to the level 1 and level 2 students in February, 1998 shortly after the beginning of the second university term.

Table 8-5: The number of students from level 1 and level 2 answered the questionnaires in February, 1998.

Level 1 = 165		**Level 2 = 53**	
Male (N=160) 132 83%	*Female (N=42)* 33 79%	*Male (N=51)* 43 84%	*Female (N=12)* 10 83%
Group I (N=132) 109 83%	*Group II (N=70)* 56 80%		

Note: percentages in the Table 8-5 calculated from the total number of females and males in the 1997/98 Physics course.

The high response rate for both courses allows us to extrapolate the results obtained on the total population of the level 1 and level 2 students.

8.6.2 Students' intentions towards Physics after the first exam

From the analyses of students' responses on the questionnaires applied in February, 1998 it was found that the picture of the level 1 Physics students [who were separated in two big groups (Group I and Group II) according their intentions towards Honours Physics at the beginning of the academic 1997/98 year (see Table 8-4)] became more complicated after the first term exams. The Table 8-6 below demonstrates the divergence which appeared inside each of the Groups (Group I - students planning a Honours Physics and Group II -students who were doing Physics as a service subject) after the first term Physics exams.

Table 8-6: Distribution of the level 1 1997/98 students according their intentions towards studying Physics (Source: questionnaires, February, 1998).

Situation on entry October, 97	Situation after exams February, 1998	Numbers
Group I (Physics degree) 109 (66%)	I A. Opt for Physics degree	73 (44%) *
	I B. Opt for level 2 but unsure about degree	21 (13%) #
	I C. Opt to leave Physics after level 1	15 (9%) ♣
Group II (not Physics degree) 56 (34%)	II A. Opt for Physics degree	6 (4%) ♣
	II B. Opt for level 2 but unsure about degree	16 (9%) #
	II C. Opt to leave Physics after level 1	34 (21%) *

Note: percentages shown are of the total responses from 1997/98 level 1 group (N=165).

The three symbols which have appeared in the Table 8-6 group students into three categories according to the stability of their initial intentions to study Physics for a degree.

♣ students whose initial intentions to behave have changed. I C and II A students changed their mind about Physics after the first term. Since the numbers in these subgroups are too small, it is difficult to determine statistically the reasons for these changes on the basis of the questionnaires. It can only be pointed out that altogether I C and II A students represent a minority when compared to the other groups.

students who became unsure about a degree subject after the first university term, but were thinking of taking Physics at level 2 (I B and II B). All together students from I B and II B subgroups can be considered as "having potential for doing Honours Physics"; they represent almost the quarter of the year group.

* students whose intention was maintained after the first university term. 34 (21%) II C students were still going to leave Physics after the level 1, while 73 (44%) I A students were still considering Physics as their proposed degree subject. This group of students represents the majority of the year group.

8.6.3. Students' intentions towards Physics after the second exam

Questionnaires applied in February, 1998 were anonymous, but it turned out that almost all students could be identified: (students were asked to indicate their gender, the school they came from, proposed degree subject and subjects taken at level 1). This was very useful for carrying out the more detailed analyses. The group of the level 1 students answered the questionnaires in February, 98 (N=165) dropped to 140, when it included those who were unambiguously identified and answered all the questions in the questionnaire. A year later (when data about students entered 98/99 level 2 Physics course became available) almost all of these 140 students could be separated into the other three groups:

1. "On level 2 students"- students who planned, entered and passed the level 2 Physics course;
2. "Withdrew students" - students who were planning to take Honours Physics at the beginning of the university course, and who planned to take Physics at level 2 after first exams, but who, in fact, left Physics after the level 1 university Physics course;
3. "General students" - students who were not planning to take Physics for Honours at the beginning of their Physics course and who followed their initial intentions and did not take Physics at level 2.

The Table 8-7 below demonstrates how these students were separated in the following groups and subgroups:

Table 8-7: Distributions of the 1997/98 level 1 students according their intentions to study Physics

Situation in October, 98	**Situation in February, 98**
"on Level 2 students" (N=76)	13 - not Honours Physics, but opt for level 2 (II B) 3 - not Honours Physics and not for level 2 (II C) 60 - Honours Physics and opt for level 2 (I A)
"Withdrew students" (N=27)	10 - Honours Physics and opt for level 2 (I A) 13 - not sure Honours, but opt for level 2 (I B) 4 - Honours Physics, but opt to leave (I C)
"General students" (N=37)	3 - not Honours Physics, but opt to level II (II A) 34 - not Honours Physics and opt to leave (II C)

Note: symbols in the brackets like (II B) are explained in the Table 8-6.

Comparing the Table 8-7 to the Table 8-6 it can be seen that:

- 96% of the "on Level 2 students" had the intention to take level 2 Physics (February, 98) and they did so (October, 98);
- 92% of the "General students" were going to leave Physics (February, 98) and they did so (October, 98);
- 85% of the "Withdrew students" were going to take Physics at level 2 (February, 98), but this intention was not expressed in the real behaviour – all of them left Physics after the first course (October, 98).

Chapter 10 is devoted to the detailed analyses of "Withdrew students" to find out the factors which might have influenced these students' decisions to leave Physics after a year of university experience in it.

8.7. Students' attitudes towards their school Physics course

One question aimed to gather information about students' attitudes towards their school Physics. The purpose of this question was to find out the effect of the attitudes, developed by students during their schooling, on their present university Physics experience. The example of the question is given below:

What are your opinions about your ***school Physics course****?*

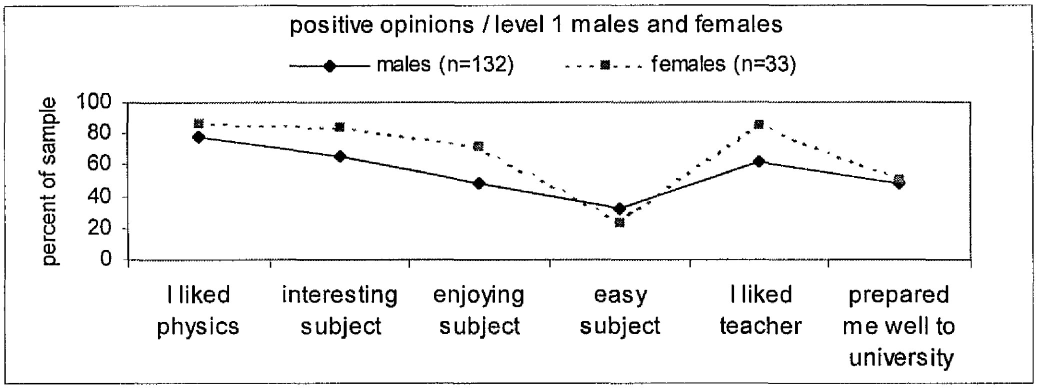
I liked Physics	☐	☐	☐	☐	☐	☐	I hated Physics
boring subject	☐	☐	☐	☐	☐	☐	interesting subject
easy subject	☐	☐	☐	☐	☐	☐	complicated subject
prepared me well for University	☐	☐	☐	☐	☐	☐	prepared me badly for University
I disliked the teacher	☐	☐	☐	☐	☐	☐	I liked the teacher
enjoying lessons	☐	☐	☐	☐	☐	☐	boring lessons

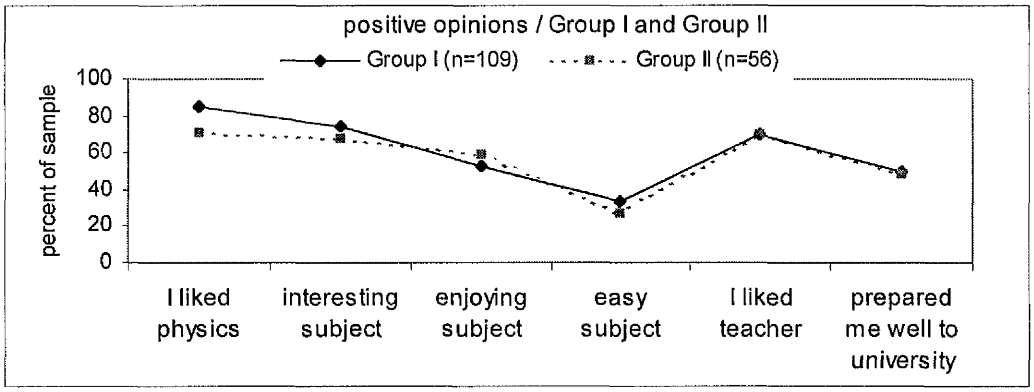
(see Appendix A, questionnaire level 1/level 2 1997/98, question 10)

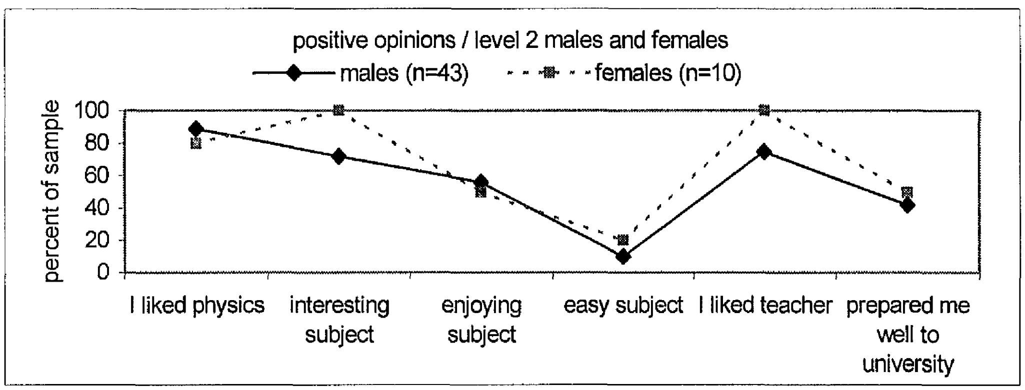
Students' responses were grouped into three categories (positive responses, neutral responses and negative responses). Comparison was made (using chi-square) between females and males, different year groups and different groups of the level 1 students (between those planning a degree in Physics and those who did not).

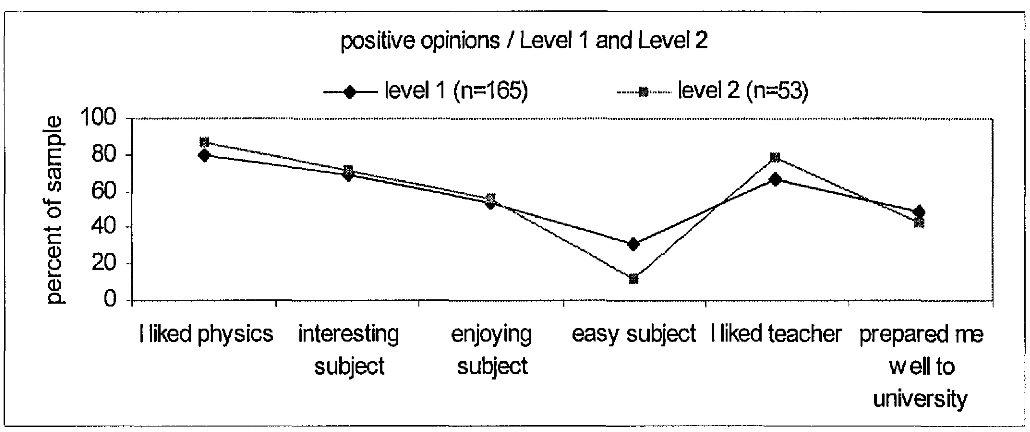
Graph 8-3 shows the distributions of responses for different groups of students. Some results will be discussed below:

Graph 8-3: Students' attitudes towards school Physics course









- *Level 1 males and females;*

Only in two cases level 1 females and males were found to be statistically different.

statements	χ^2	***df***	***significance***	***favoured****
"I liked*/disliked the teacher"	4.35	1	< 5%	females
"enjoying*/boring lessons"	6.67	1	< 1%	females

In both cases females' attitudes towards a teacher and lessons were significantly more positive than those of males. It seems that females who have taken Physics at the university were more inspired by their school teacher than males and Physics lessons were more enjoyable for them than for males. (Full data are in the Appendix P, p. 1).

- *Level 2 males and females;*

Statistically no differences in responses of females and males were found. Although, it is interesting to note, that all females expressed extremely positive views on the subject itself and attitudes towards their teacher. Males were also positive, but not as much as females (see Graph 8-3). Full data are in the Appendix P, p. 2.

These results are interesting to discuss. It has been reported that a Physics teacher and his/her attitudes towards girls studying Physics are extremely important factors in promoting girls' positive attitudes towards Physics as well as in attracting girls to Physics (Weinberg, 1998; Seymour and Hewitt, 1997). Not one of the females who entered the level 2 university Physics course indicated that she either disliked or even held a neutral opinion about the school teacher. All of them were extremely positive. For many of them it might have been a teacher who inspired, encouraged and influenced their positive attitudes towards Physics and stimulated them to study it at a university level.

A correlation analysis (Kendall's *tau-b)* was performed for 1997/98 level 1 females and males to find out what kind of associations students have with their school teacher. The results are in the Table 8-8 below. (Full data are in the Appendix K, pp.4-5).

Table 8-8: Correlation analysis for 1997/98 level 1 males and females

I liked the teacher/	**Females (N=28)**	**Males (N=87)**
correlated with	*tau_b*	*tau_b*
I liked physics (at school)	0.63**	0.52**
Interesting subject (at school)	0.57**	0.46**
Lecturers interesting (at the university)	0.03	0.24**
I am growing intellectually (at the university)	-0.18	0.19*
I am enjoying subject (at the university)	-0.13	0.19*

* correlation is significant at 5% level (2-tailed test)
** correlation is significant at 1% level (2-tailed test)
Note: shaded boxes mark associations, which are interesting to discuss.

It can be seen from the Table 8-8, that for females, their perceptions of the teacher have significant positive associations with their attitudes towards Physics only at school level, while there are significant positive associations of the teacher with university experience, as well as school experience, for males. It looks as if males who liked their teacher at school continued enjoying lectures at the university, felt that they were obtaining lot of new skills and growing intellectually and, in general, enjoying Physics at the university. For females the experience in the university Physics looks different. Attention should be paid to the negative associations found between the teacher and feelings of intellectual growth and enjoyment of Physics in the university Physics course for female students (Table 8-8). Although these associations were not significant, they were negative, and the possibility cannot be rejected that they would become significant if a larger sample had been considered.

The results of the correlation analyses (Kendall's *tau-b)* between students' attitudes towards school Physics and different factors of their school and university experience in Physics can be seen in the Table 8-9 below.

Table 8-9: Correlation analysis for 1997/98 level 1 females and males

I liked Physics (at school)	**Females (N=28)**	**Males (N=87)**
correlated with	*tau_b*	*tau_b*
I liked the teacher	0.63**	0.52**
Interesting subject (at school)	0.62**	0.55**
Easy subject (at school)	0.25	0.19*
Course easy (at the university)	0.18	0.27**
I am obtaining a lot of new skills (at the university)	0.10	0.19*
Lecturers interesting (at the university)	0.14	0.33**
I am growing intellectually (at the university)	0.01	0.28**
I am enjoying subject (at the university)	0.00	0.32**
It is definitely "my" subject	0.32	0.32**

* correlation is significant at 5% level (2-tailed test)
** correlation is significant at 1% level (2-tailed test)
Note: shaded boxes mark associations which are interesting to discuss.

It looks as if females' positive experience in school Physics, which is associated so strongly with their school teacher, has very little association with their present university Physics course, while there were found several positive significant associations between males' experience in school Physics and their present experience in the university Physics course (Table 8-9). It would seem that males do not need their school teacher as much as females in maintaining their confidence in and positive attitudes towards Physics.

- *Group I – students planning a degree in Physics* and *Group II – students not planning a degree in Physics;*

The only difference between these two groups was found regarding attitudes towards Physics:

statements	χ^2	***df***	***significance***	***favoured****
"I liked*/hated Physics"	11.7	1	< 1%	Group I

Group I students' attitudes towards their school Physics were found to be more positive than Group II students' attitudes. This result stresses once again that attitudes towards Physics play a very important role in the subject enrolment for a degree. (The full data are in the Appendix P, p. 2)

- *Level 1 and level 2* students were very similar about their school Physics experience. (The full data are in the Appendix P, p. 4)

The general picture that emerges from the analyses of students' attitudes towards their school Physics experience reveal that those students who decided to study Physics at university perceived their school Physics experience as very successful in terms of:

- interest towards subject;
- enjoyment of subject and
- as a good preparation for university Physics course.

Teachers seem to be playing a very important role in forming students' attitudes towards Physics, and this is particularly true for females.

8.8. Factors influencing students' choice of Honours

One question in the questionnaire sought information about factors influencing students' choice of Honours subject(s):

*Which factor(s) influenced your choice of **Honours** subject(s)?*

- ☐ Enjoyment of subject
- ☐ Good grades at school in subject
- ☐ Your teacher at school
- ☐ Your parents
- ☐ Information from mass media
- ☐ Friends
- ☐ Likely career opportunity
- ☐ Demonstrations, exhibitions
- ☐ Any other factors____________

(See Appendix A, questionnaire level 1/level 2 (1997/98), question 5)

Since about 88 percent of students doing Physics in 1997/98 academic year were going to do either a Science or Mathematics subject(s) for a degree (see Diagram 8-1), the answers on this question can reveal the reasons for studying these subjects for Honours. The analysis was performed using the Theory of Planned Behaviour (Chapter 3, p.34) and the following factors were included as options in the question:

- attitudinal factors, such as interest and enjoyment of subject;
- perceived behavioural control factor, such as good grades at school;

- subjective norm factors, such as the teacher, parents, friends, career opportunities.

Such factors as demonstrations, exhibitions, festivals, information from mass media were also included to find out what kind of impact they had on students' intentions about Honours subject(s). Students could choose as many options as they felt would be appropriate to explain their choice of Honours subject(s). An open ended option like "*any other factors*" was also included to give students an opportunity to answer the question more precisely.

The comparison of factors influenced students' choice of Honours subject(s) (using a chi-square) was performed separately for:

- Level 1 males and females;
- Level 2 males and females;
- Level 1 and level 2 students.

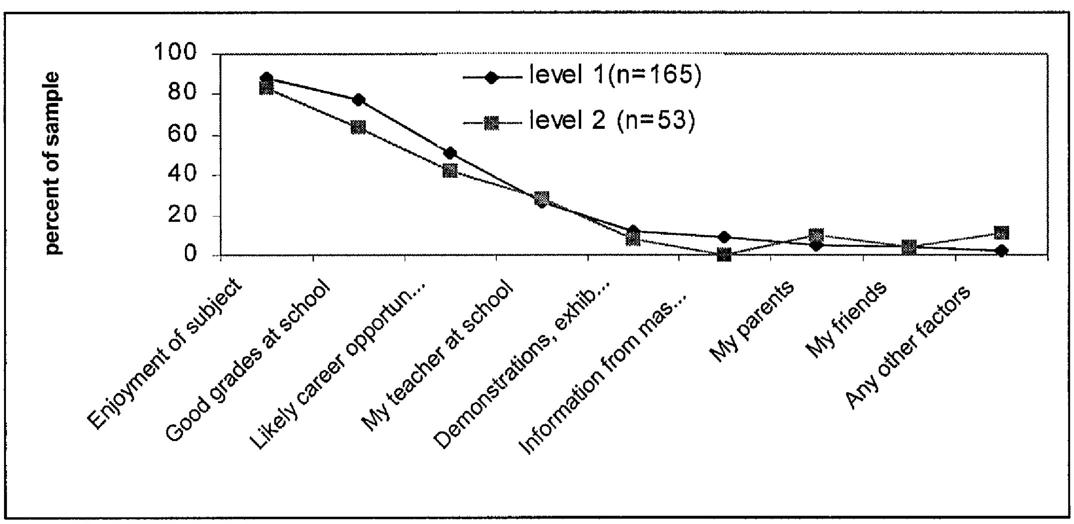
Statistical analysis of responses gave rise to the following picture:

- Level 1 males and females - no differences found;
- Level 2 males and females- no differences found;
- Level 2 and level 1 students - no differences found.

(see Appendix O. p. 1 for detail).

The distribution of factors which influenced students' choices of Honours subject(s) is shown on the Graph 8-4 for the level 1 and the level 2 students.

Graph 8-4: Distribution of factors which influenced choice of particular Honours



subject(s)

For the total population of 218 students (165 level 1 + 53 level 2) four factors can be detected with a response rate higher than 15%:

	%
1. Enjoyment of subject	87
2. Good grades at school	74
3. Likely career opportunity	49
4. My teacher at school	27

Enjoyment of the subject was found to be the most important factor determining students' choice of Science subjects or Mathematics for a university degree:

- "enjoyment of subject" was found to be significantly more important than "good grades at school" (*χ^2 =12.23 is significant at 1% when df=1*), while
- "good grades at school" were found to be significantly more important than "likely career opportunity" (*χ^2 =28.23 is significant at 0.1% when df=1*), and
- "likely career opportunity" was more important factor than the teacher at school (*χ^2 =22.41 is significant at 0.1% when df=1*).

From these results it emerges that the attitudinal component (*AB*) ["*enjoyment of subject*"] of the behaviour [*choice of the Honours subject(s)*] is playing the most significant role in determining school pupils' intentions about a science-related subject for a degree, and this is true for both sexes. Even though pupils can be successful in different science subjects, it appears that they will be unlikely to decide to take these subjects for the further study if they neither enjoy them nor find them interesting. Perceived behavioural control factor (*PBC*), determined through "*good grades at school*" which can be interpreted as knowledge and skills and confidence is also playing an important role. The role of the teacher, which can be attributed to the subjective norm factor (SN), is obviously, less influential on the intention to take Physics for Honours than the roles of the first two factors (however the teacher might play a significant role on students' attitudes towards the subject and achievement in it). It is surprising, that parents and friends were hardly considered as salient references when it comes to making choice of the subject for Honours.

In the work of Seymour and Hewitt (1997) where they surveyed students doing a Science-Mathematics-Engineering (SME) major at different universities in the USA they found that "the most marked difference between sexes lies in their choice of major". Women were about twice as likely as men to have chosen an SME major through the active influence of someone significant to them (family members, teacher, friends). Moreover, an active influence of others (pressures from or persuasion of people significant to students) was found to be one of the dominant factors determining American students' choice to take science subjects at university. Much of this influence came from the family members, especially for those students whose parents were financing their undergraduate education. Nothing like this was found with the experimental groups of students (level 1 and level 2) who participated in the present research. Moreover, no differences were found between females' and males' reasons for entering the Physics department.

Such factors as parents and friends, as well as information from mass media, different exhibitions and festivals were found to be of low significance in determining students' choice of a degree subject at university.

8.9 Factors influencing choice of university

Students were asked about the criteria they think were important in determining which University to enter after school? The question is shown below:

Why did you choose Glasgow University?

☐ Only University which offered me a place	☐ Good academic reputation
☐ Best one for subject(s) I wanted to study	☐ Near my home
☐ Only University, which runs the course, I wanted to take	☐ No other choices for me
☐ University seemed to offer excellent extra facilities	☐ Recommended to me

(See Appendix A, Questionnaire level 1/level 2 1997/98, question 3)

Students could indicate as many factors as they wished.

The comparison analysis of students' answers (using chi-square) was done separately for:

- Level 1 males and females ;

- Level 2 males and females;
- Level 1 and level 2 students.

No differences were found between any of the compared groups. The full data are in the Appendix O, p. 2.

Since no differences were found neither between genders, nor between different year groups, general conclusions were drawn for the total population of the 218 (165 level 1 +53 level 2) students. Out of eight factors suggested, five emerged with response rates greater than 15%. These factors are:

	%
1. Good academic reputation	83
2. Near my home	54
3. Best one for subject(s) I wanted to study	53
4. University seems to offer excellent extra facilities	36
5. Recommended to me	31

As can be seen from the analysis above, the most important factors determining students' choice to enter the University of Glasgow was its' "*good academic reputation*". The factor of closeness to home was also found to be important for both level 1 and level 2 students. The vast majority of level 1 and level 2 Physics students of the University of Glasgow are of Scottish domicile. As it was pointed elsewhere (National Committee of Inquiry into Higher Education, 1997; Higher Educational Statistics for the United Kingdom, 1996/97) Scots show "*a clear proclivity to study in Scotland"; e.g. in "1994/95, 95 per cent of Scottish full-time entrants to Higher Education in the UK choose to study in Scotland*". Compared to the rest of the UK, Scots tend to study close to home: only one in fifteen Scottish students normally move outside their region to attend a Higher Educational Institution compared with two out of five students from the other regions of the UK (Higher Educational Statistics for the United Kingdom, 1996/97). (For the experimental group of 1997/98 level 1 Physics students, 89 percent were from Scotland).

Such factors as

- "only University which offered me a place"
- "only University which runs the course(s) I wanted to take"
- "no other choices for me"

were found to be not important in determining students' choice of the university. This means that students were free in their choice of the university to study and they preferred to go to that one which is known by its academic reputation, is the best one for subject(s) they wanted to study and not far away from the home.

8.10 Students' expectations from and their fulfilment in the Physics course

Being interested in Physics and enjoying it at school level, being successful in it and being happy about a teacher, students took a decision to go to the university of their choice and study Physics - some for a degree, some just for one year.

One of the possible reasons for leaving Physics after a year of university experience could have been because of the disappointments from the course for some students, when the expectations students had after school about university Physics course and the reality were not met. That is why it was decided to examine the spectrum of expectations which students had about the university Physics course and how these expectations had been fulfilled. Students from the level 1 and level 2 were surveyed.

8.10.1 Students' expectations from the university Physics course

The question which aimed to investigate students' expectations from the Physics course was presented in the following way:

Before coming to Glasgow University, what were your expectations from the Physics course?

□ developing new or existing skills	□ deeper understanding of subject
□ increasing my self-confidence in Physics	□ learning about new ideas
□ preparing for a career	□ broadening my horizon
□ experiencing intellectual growth	□ obtaining practical skills
□ having a good time	□ meeting new people

(see Appendix A, Questionnaire level 1/level 2 1997/98, question 8 for details)

The question was a closed one, where students were provided with ten options from which they could choose as many as they feel would reflect the range of their expectations. All these options can be grouped into four categories:

1. *expectations about personal development* ("developing new or existing skills", "increasing my self confidence in physics", "obtaining practical skills");

2. *expectations about intellectual development* ("experiencing intellectual growth", "deeper understanding of subject", "learning about new ideas", "broadening my horizon") ;
3. *expectations about social developments* ("meeting new people", "having a good time");
4. *expectations about preparing for a career* ("preparing for a career").

The comparison analyses of students' expectations (using a chi-square) were carried out for:

- Level 1 males and females (to see the differences in expectations between genders, if any);
- Group I - students planning to do a degree in Physics and Group II - students planning to do other (not Physics) subject(s) for a degree to compare expectations of more committed and less committed to Physics students;
- Level 2 males and females, (to see the differences between genders and to provide the comparison background for level 1 males and females);
- Level 1 and level 2 students, (to compare the expectations of more selected level 2 group with level 1).

Graph 8-5 below shows the distribution of students' responses separately for these four groups. Table 8-10 shows the results of the statistical analyses. Some results are discussed below.

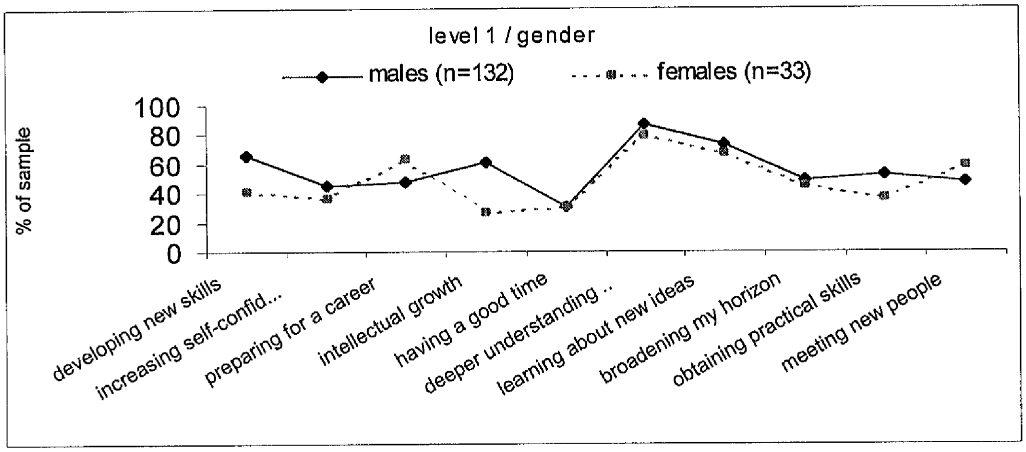
- *Level 1 females and males;*

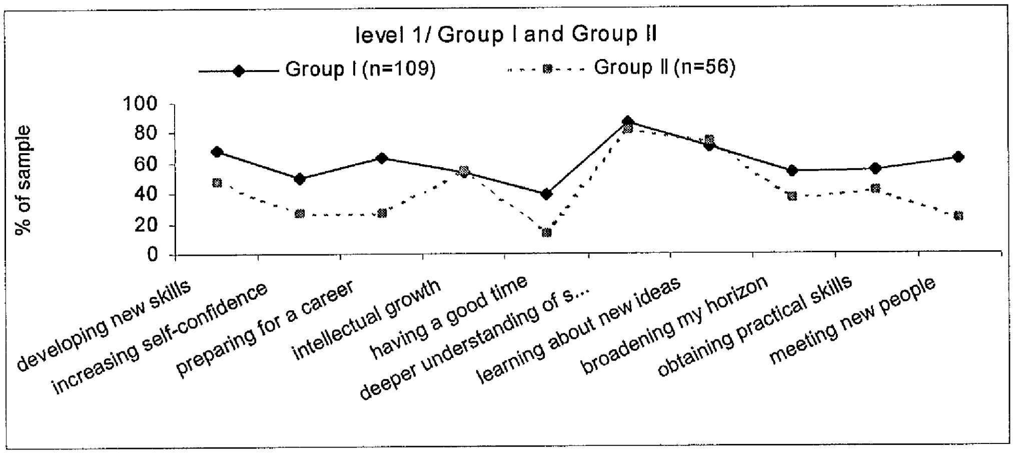
In two cases males' expectations were significantly higher than females. These expectations are about "*experiencing intellectual growth*" and "*developing new or existing skills*" (see graph 8-5). The whole data are in the Table 8-10.

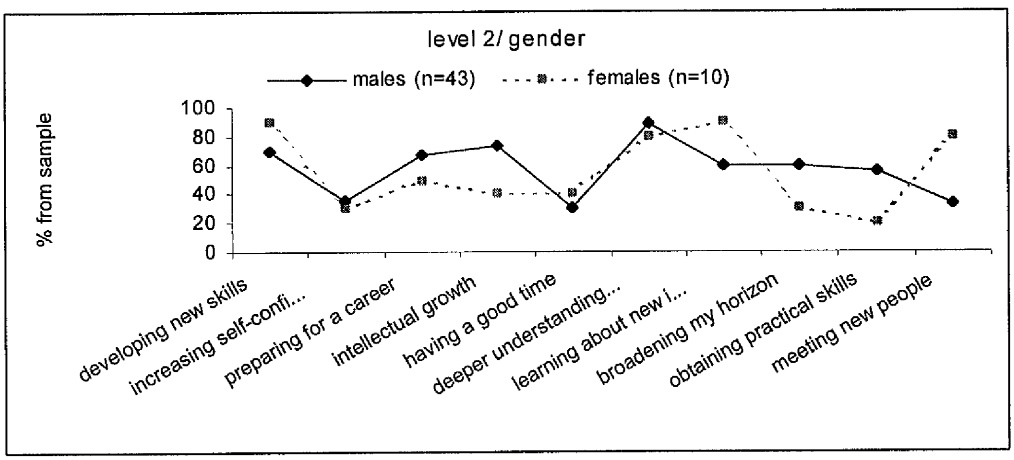
- *Level 2 males and females*;

Only one significant difference between females' and males' expectations was found. This difference is in the expectations about "*meeting new people*". More females expected to meet new people than males. Due to small sample of the level 2 females statistical analyses of some responses were not possible to perform. See Table 8-10 for full data.

Graph 8-5: Students' expectations from the university Physics course







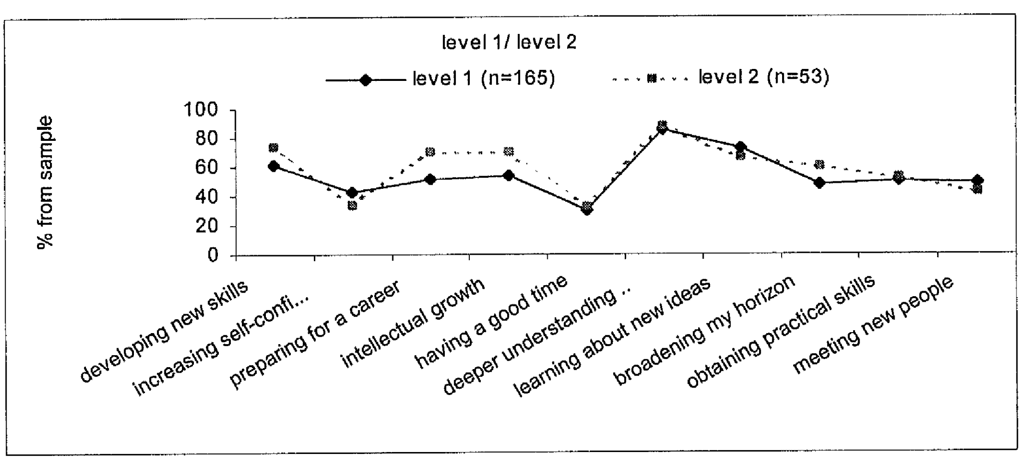


Table 8-10: Level 1 and level 2 students' expectations from the university Physics course (97/98)

	Level 1			Level 1			Level 2		
	Female (N=33) %	Male (N=132) %	χ^2	Group I (N=109) %	Group II (N=56) %	χ^2	Female (N=10) %	Male (N=43) %	χ^2
developing new or existing skills	42	66	6.4*	72	48	6.1*	90	70	1.7
increasing my self-confidence in Physics	36	45	0.9	52	27	7.6**	30	35	-
preparing for a career	64	48	2.7	61	27	13.6**	80	67	0.6
experiencing intellectual growth	27	61	12.3**	56	55	0.0	50	74	2.3
having a good time	30	30	0	39	13	12.0**	40	30	0.4
deeper understanding of subject	79	86	0.9	87	82	0.8	80	88	0.5
learning about new ideas	67	73	1.0	69	75	0.5	90	60	3.2
broadening my horizon	45	49	0.2	56	36	4.4*	60	60	0
obtaining practical skills	36	53	3.1	54	41	1.8	40	56	0.8
meeting new people	58	47	1.3	61	23	18.1**	80	33	7.5**

* means significance at 5% level of probability
** means significance at 1% level of probability
df=1 for every option suggested

- *Group I – students planning a degree in Physics and Group II students not planning a degree in Physics* were very similar in their expectations from the Physics course about "*deeper understanding of subject*", "*learning about new ideas*" and "*experiencing intellectual growth*" (see Graph 8-5). These expectations were among the highest for students from both Groups. It can be suggested that, if these expectations are met by the department, more students from the Group II might be attracted into Physics and more students from the Group I would be kept in it. In the rest of the expectations, as expected, where there are differences, expectations of Group I students were higher than expectations of Group II students. See Table 8-10 for details.

- *Level 1 and level 2 students;*

Expectations of the level 2 students were significantly higher than expectations of the level 1 students about "*preparing for a career*" and "*experiencing intellectual growth*". Since the vast majority of the level 2 students were planning to take Physics for Honours (96% of the level 2 students participated in the research were planning about a degree in Physics), it is to be expected that their expectations about preparing for a career should be higher than those for the total population of the level 1 students. The difference between the level 1 and level 2 students' expectations about "*experiencing intellectual growth*" can be explained by the significant contribution of the level 2 females to this factor: all the level 2 females indicated that they were planning to take Physics for a degree, and their expectations regarding "experiencing intellectual growth" were found to be higher than ones of the level 1 females.

Comparing expectations of the level 2 and Group I (students from the level 1 planning a degree in Physics) the following picture was obtained:

Table 8-11: Level 2 and Group I expectations from the university Physics course

	Statements suggested	Group I (N=109)	Level 2 (N=53)	χ^2	significance	favoured
1	deeper understanding of subject	87	87	0	ns	-
2	developing new or existing skills	72	74	0.07	ns	-
3	learning about new ideas	69	66	0.15	ns	-
4	preparing for a career	61	70	1.25	ns	-
5	meeting new people	61	42	5.20*	5%	Group I
6	experiencing intellectual growth	56	70	2.93	ns	-
7	broadening my horizon	56	60	0.23	ns	-
8	obtaining practical skills	54	53	0.01	ns	-
9	increasing my self-confidence in Phy	52	34	4.65*	5%	Group I
10	having a good time	39	32	0.75	ns	-

Note: df=1

Two differences have emerged between level 2 and Group I students in favour of Group I students. Neither in "*preparing for a career*" nor in "*experiencing intellectual growth*" level 2 and Group I students were found to be different. That is why it can be suggested that the differences in expectations found between the level 1 and the level 2 students were mainly because of the differences in expectations between uncommitted to Physics students from the Group II and the level 2 students.

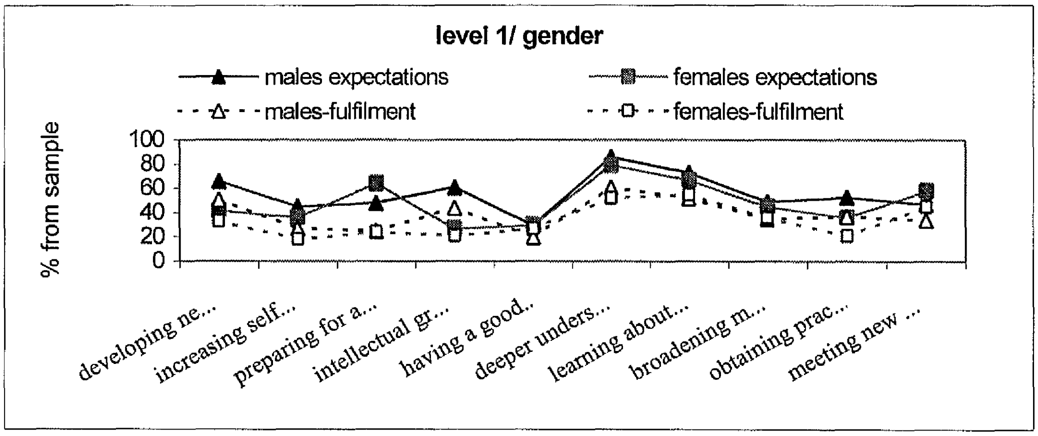
In general, students' expectations from the university Physics course were mainly about intellectual and personal developments, like:

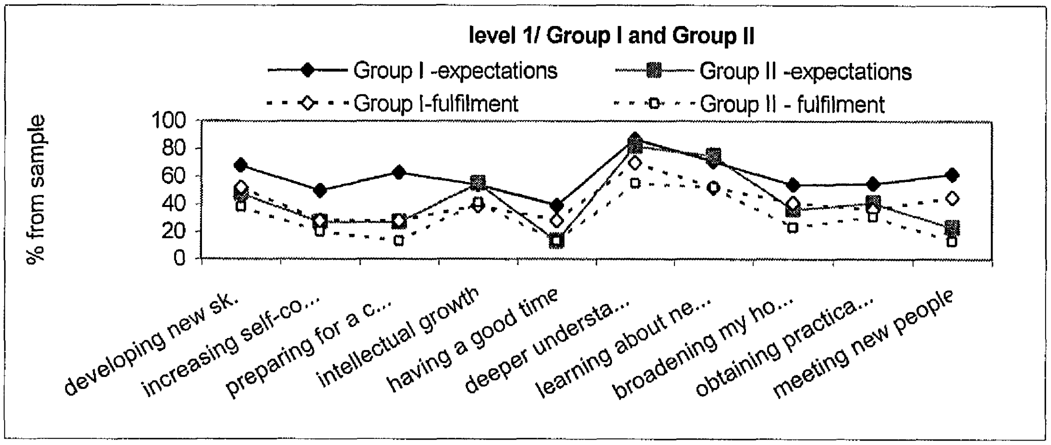
- deeper understanding of subject;
- experiencing intellectual growth;
- learning about new ideas;
- developing new or existing skills;
- preparing for a career.

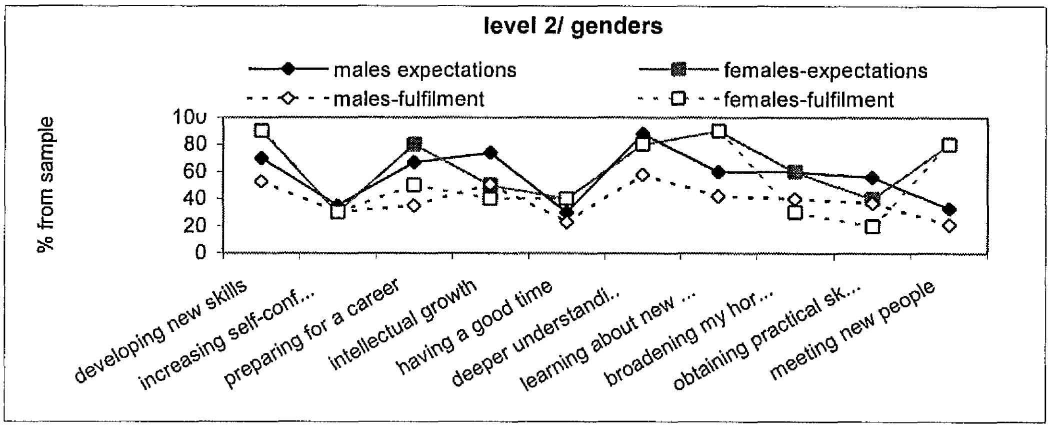
8.10.2. Fulfilment of students' expectations

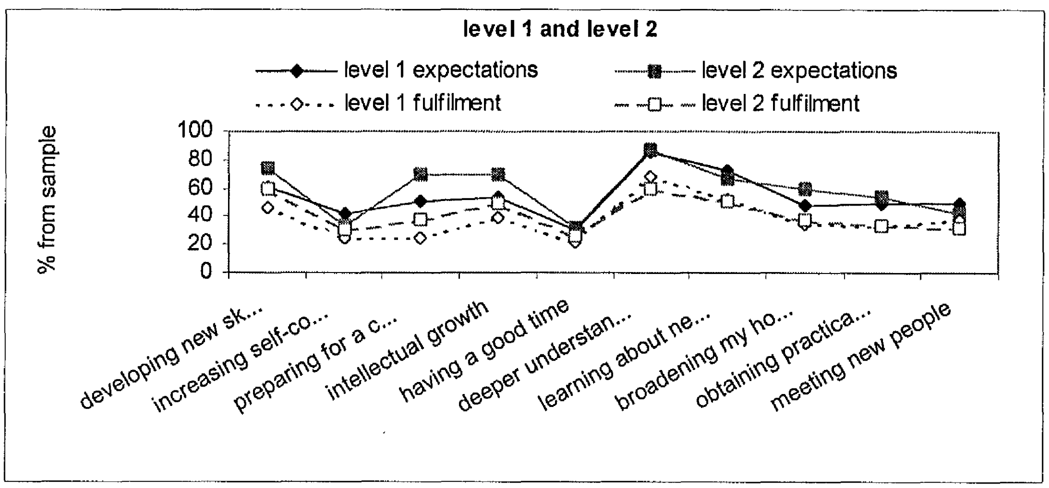
The extent to which students' expectations have been met by the university Physics course can be judged by comparing students' experiences they have gained from the course with their aspirations from the course before they entered it. Analysis of students' expectations fulfilment was performed separately for males (level 1 and level 2); females (level 1 and level 2); Group I (Group II); level 1 students and level 2 students.

Graph 8-6: Students' expectations from the Physics course and their fulfilment.









The whole data related to these analyses are in the Appendix O, pp. 3-6. The Graph 8-6 above allows to trace differences in expectations and their fulfilment for different groups of students. Discussion of some results is done below:

Looking separately at level 1 females and males expectations and their fulfilment, it was observed that although their expectations were very similar (see Graph 8-5 and Table 8-10) the picture of their fulfilment looks very different.

- *Level 1 males (N=132):* almost all (nine out of ten) level 1 males' expectations have not been fulfilled during the first university term. Only expectations *about "having a good time*" [the lowest one (see the Table 8-10)] have been fulfilled. The full data are in the Appendix O, p. 3.

- *Level 1 females (N=33*): Almost all level 1 females' expectations have been met by the department by the beginning of the second university term. Only in two cases females' expectations were higher than their fulfilment: "*preparing for a career*" and "*deeper understanding of subject*". The full data are in the Appendix O, p.3.

How can these observed differences in females' and males' expectations fulfilment be explained: having similar expectations from the Physics course and, being in the same course of the same duration, females have more or less received what they expected, but males have not?

The differences in the expectations and their fulfilment about "*meeting new people*" and "*obtaining practical skills*" found between females and males could probably be explained in terms of the marked social concepts and personality differences of males and females observed back to school. Boys normally develop more practical skills than girls through home and school activities. This is mainly due to the nature of their interests and activities, which are shaped by social stereotypes of boys (ways boys are brought up). That is why boys normally demonstrate a higher level of instrumentality, which means more experience in working with technical objects and apparatus, than their female peers. Expectations of males and females about "*obtaining practical skills*" were found not to be different *quantitatively* (see Table 8-10), but they might have been different *qualitatively* . That is why practical skills obtained by the second university term through e.g. laboratory practice and IT classes, could fulfil females' expectations about obtaining practical skills, but not for males. Males' expectations about this part of their personal development seems to be different from females and it looks that such expectations of males are more difficult to fulfil than of females.

However, females are more sociable and person oriented than males (Smithers and Hill, 1987). That is why it might be much easier for females than for males to "meet new people" and have a richer social life in the university, i.e. quicker than males fulfil their expectations about social developments. Males seem to need much time for this.

The picture obtained for the *level 2 females and males* expectations and their fulfilment looks, in general, similar to the picture obtained for the level 1 students: almost all expectations of the level 2 females look like being met, but level 2 males still have no feelings of fulfilment of their expectations about "*preparing for a career*", "*deeper understanding of subject*" and "*experiencing intellectual growth*. The full data are in the Appendix O, p. 5.

The general picture of expectations and their fulfilment for the total level 1 and level 2 students show patterns similar to patterns observed for level 1 and level 2 males (Appendix O, p. 6).

The picture obtained of students' expectations from the Physics course and their fulfilment showed that the Physics department meets students' expectations rather slowly, especially males expectations. Even level 2 students still have no feelings that their expectations about "*deeper understanding of subject*", "*experiencing intellectual growth*" and "*preparing for a career*" were met. Following these results it is valid to assume that some students might get disappointed, many among male students.

Males' expectations related to their personal and intellectual development looks like being poorly met by the department, but the picture is different for females. Observed differences between females and males expectations fulfilment lead us to suppose that "quality" of females and males expectations from the Physics course were different.

8.11. Conclusions

A summary of the general results obtained from the analyses performed in this Chapter is following:

1. The entry qualifications in Physics and Mathematics of students doing the 1997/98 Physics course in general and those planning a degree in Physics were very high.

2. The choice of the university in which to study was largely determined by three factors:
   1) good academic reputation of the university;
   2) university vicinity to students' home;
   3) high rating of the university for subject(s) students wanted to take.

   For Scottish domiciled students the factor of closeness to home was found to be very important. Scots show a tendency to study in Scotland.

3. Those students who decided to study Physics at university perceived their school experience in Physics as very successful in terms of interest, enjoyment and good preparation for university. The teacher was found to be playing a very important role in forming attitudes towards Physics especially regarding girls.

4. The choice of Physics as a degree subject was largely determined by four factors:
   a) enjoyment of Physics at school;
   b) success in Physics at school;
   c) perceived career opportunities arising from Physics;
   d) Physics school teacher.

   The first factor was significantly more important than the others both for males and females.

5. The ratio of males to females for students planning a degree in Physics was equal to three. The ratio of males to females is lower for Combined Honours Physics, indicating that more females were planning a degree in Physics plus in another subject, than in a Single Honours Physics.

6. Physics teacher appeared to have strong positive associations with students' positive experience in Physics at school, both for male and female Physics students. However, it was observed that confidence in doing Physics at university of some female students may suffer because of the lack of the contact with their school Physics teacher and/or personal contact with a university teacher. Nothing like this was observed for male students.

7. The University Physics course meets students' expectations rather slowly and this is particularly true for male students. Expectations which students pointed as have not been met by the second term of the second course were about "deeper understanding of subject", "experiencing intellectual growth" and " preparing for a career".

Chapter 9

Students' attitudes towards university Physics

9.1. Introduction

According to the Theory of Planned Behaviour (Ajzen, 1985), the intention to behave as well as behaviour itself can be predicted if three factors are known:

- attitude towards behaviour [*AB*] (advantages or disadvantages of being involved in the behaviour, e.g. studying Physics for Honours),
- subjective norm factors [*SN] (*approval or disapproval of important people towards engaging in the behaviour, e.g. parents, teachers, general attitudes of the society) and
- perceived behavioural control [*PBC*] (skills, knowledge, abilities, efforts required to perform the behaviour).

It was revealed from the analyses performed in the previous Chapter that the role of subjective norm factor (*SN*) was weak in determining students' choice of a science-related Honours subjects. No differences were found between females and males. It was also found that the entry qualifications of students planning a degree in Physics were high, and males and females were similar. The emphasis in this Chapter is given to analysis factors influencing attitudes towards the behaviour *(studying Physics for Honours*) (*AB*) like students' attitudes towards university Physics course, students' perceptions of self in Physics course, students' attitudes towards Physics. Control beliefs of the perceived behavioural control factor *(PBC)* of the behaviour will be explored through analyses of students' evaluations of the course difficulty and work load in the course (Crawley and Black, 1992).

In the previous Chapter it was found that positive attitudes to Physics at school ("*enjoyment of Physics*") was the major significant factor which influenced students' choice of Physics for Honours. It might be expected that attitudes towards university Physics course will play the most significant role in students' decisions to continue or not to continue studying Physics for a degree. As in the case with school pupils, it was hoped that, from the picture of students' attitudes towards the university Physics course, it might be possible to judge the success or failure of different university teaching approaches in promoting and maintaining students' positive attitudes towards Physics.

9.2. Students' attitudes towards university Physics

In the first set of the questionnaires applied in February, 98 three questions were devoted to attitudes:

- the first one was about students' attitudes towards the Physics course in terms of lectures, laboratories, tutorials, work level, mathematical aspects of the course, course difficulty and work load in the course;
- the second one was about students' perceptions of self in the university Physics course in terms of students' feelings about their progress in the course, enjoyment of subject, their intellectual growth and obtaining practical skills, their perceived improvements in subject, and
- the third one was devoted to an investigation of students' attitudes towards organisational aspects of the Physics course in terms of the general organisation of the course, assessment methods used, time demands, support from academic staff.

(See Appendix A, Questionnaire level1/level 2 97/98, questions 11, 12, 14).

9.2.1. Students' attitudes towards the university Physics course

To construct a picture of students' attitudes towards their university Physics course, the same method was used as for analyses of pupils' attitudes. The question is shown below:

How did you find the Physics course at the University?

Lectures boring	☐	☐	☐	☐	☐	☐	Lectures interesting
Laboratories interesting	☐	☐	☐	☐	☐	☐	Laboratories boring
Tutorials helpful	☐	☐	☐	☐	☐	☐	Tutorials waste of time
Course too mathematical	☐	☐	☐	☐	☐	☐	Course not mathematical enough
Course difficult	☐	☐	☐	☐	☐	☐	Course easy
Work level demanding	☐	☐	☐	☐	☐	☐	Work level undemanding

(Appendix A, Questionnaire level 1/level 2 97/98, question 12)

Students' responses were grouped into three categories (positive responses, neutral responses and negative responses). Comparisons were made between females and males, between different groups of the level 1 students (those planning to do Honours Physics and those who not planning to do this) and between different age groups (level 1 and level 2). The chi-square statistic was employed to test for significance.

The Graph 9-1 below (p.160) represents the distribution of "positive" responses for these groups of students. Full data are in the Appendix L, pp. 1-4. Some results will be discussed below:

- *Level 1 females and males;*

Only in two cases, the level 1 males' and females' attitudes were different. For the level 1 females the Physics course looks more difficult than for males and significantly more females than males consider the work in the Physics course as very demanding (see Graph 9-1 below and Appendix L, p.1).

In the research project with school pupils where intentions of pupils to enrol in Physics at school were explored, it was shown that these two factors (*difficulty of the course* and *work load in the course*) were attributed to factors which can turn pupils' away from studying Physics. According to the Theory of Planned Behaviour (p.34) these two factors can be considered as control beliefs that build the perceived behavioural control factor (*PBC*) of the behaviour *studying Physics for Honours*. It appeared that the level 1 females' *PBC* factor of the behaviour was lower than for males.

The average exam results for 97/98 level 1 Physics, for both genders are shown separately in the Table 9-1:

Table 9-1: Average exam results for 1997/98 level 1 Physics students

Level 1	**Module 1 exam results**		**Module 2 exam results**	
	score	**grade**	**score**	**grade**
females (N=42)	2.2 (N=41)	**B**	2.2 (N=37)	**B**
males (N=160)	2.6 (N=154)	**C**	2.7 (N=131)	**C**

Note: Because exam results for both modules were obtained as Grades (A, B, C, etc..) the following system was used 1- A, 2 - B, 3 - C, 4 - D, etc.. to calculate their averages. That is why the *lower* the score in the Table 9-1, the *higher* the Grade it represents.

It is interesting to note that females, for whom the Physics course looks more difficult performed on average better than males in both term exams (Table 9-1). The same tendency was observed back in school: girls who stay in Physics tend to outperform boys (Stewart, 1998). However, no difference was observed between genders regarding perceptions of the subject difficulty in school.

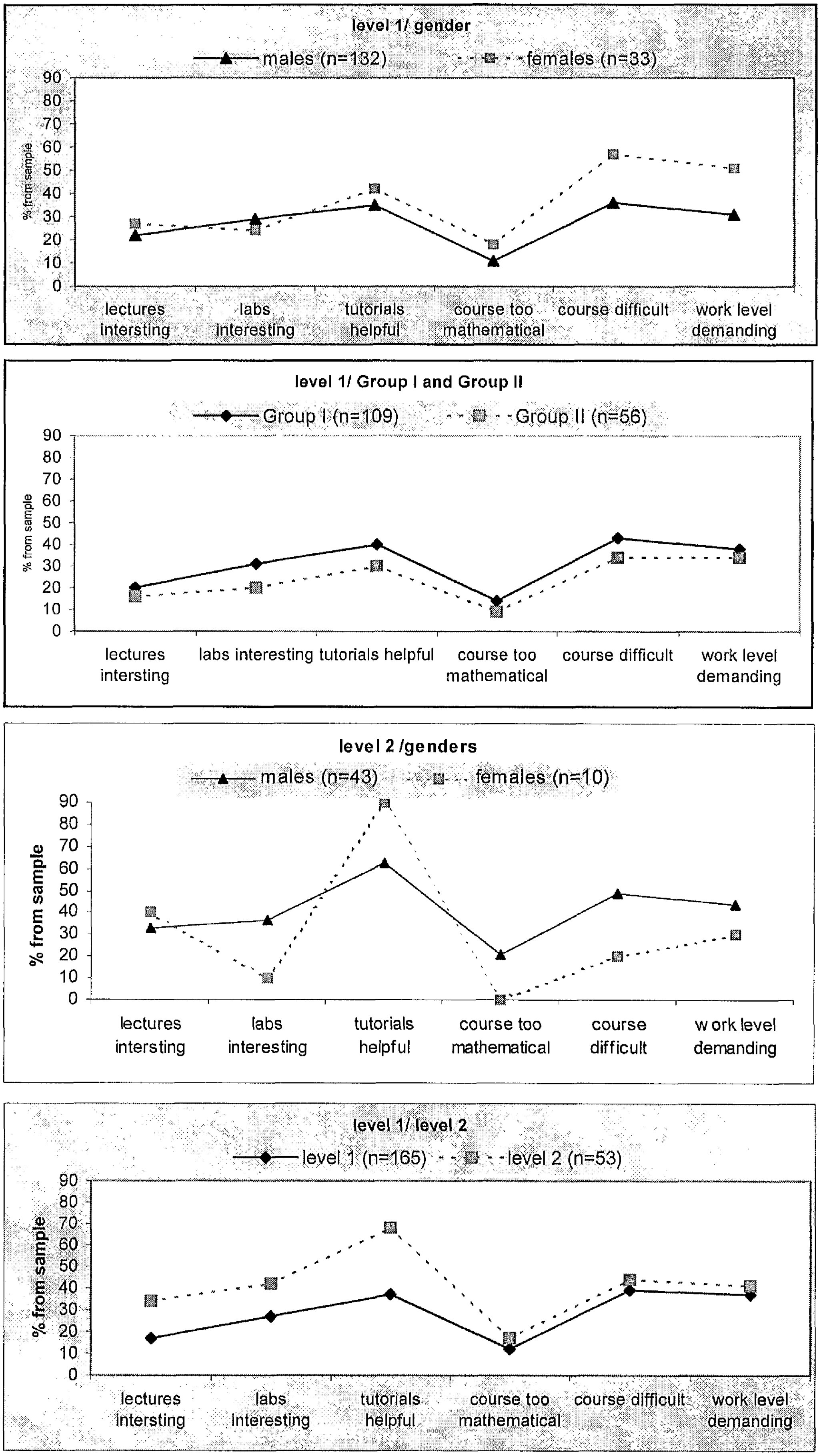
- *Level 2 males and females;*

No differences were found in the attitudes of the level 2 males and females towards their Physics course using chi-square statistics. Due to the small sample of the level 2 females, statistical treatment of some responses was impossible. The full data are in the Appendix L, p. 3.

- *Group I - and Group II students;*

No differences were found. Students' evaluations of lectures, laboratories, tutorials, level of difficulty of the course and work load in the course were similar by those who were planning to study Physics for Honours (Group I) and by those who were doing Physics as a supportive subject (Group II). The full data are in the Appendix L, p.2.

Graph 9-1: Students' attitudes towards university physics course



- *Level 1 and level 2 students;*

Two differences were observed:

statements	χ^2	***df***	***significance***	***favoured****
lectures interesting*/boring	6.2	2	< 5%	level 2
tutorials helpful*/waste of time	15.6	2	< 1%	level 2

(Full data are in the Appendix L, p. 4). Level 2 students were found to be more positive than their younger level 1 peers about tutorials and the course of lectures in their Physics course. Later on, during the semi-structured interview which took place in May, 1999 (see Appendix R with full report of the interview), it became clear that the level 1 as well as level 2 students found the second term of their level 1 Physics course more interesting than the first one:

- there was less repetition of the material learned at school,
- topics were more exciting and interesting (such as quantum mechanics, properties of matter, for example).

At level 2, the course of lectures became even more interesting since second year generally offers a wider choice of modules along with deeper context, which, as it was found, is more appealing to students.

9.2.1.1 Problems associated with course of lectures

The observed dissatisfaction of some level 1 students about course of lectures given to them during their first university Physics course is in total agreement with some expressed disappointments of first course Physics students who seemed to be looking forward to studying "modern" Physics right from the beginning of the university Physics course.

> *"According to the survey by the UK's Particle Physics and Astronomy Research Council, it is precisely these areas of so-called "sexy physics" - cosmology, chaos, elementary particles and the like - that attracts most undergraduate physics students to the subject. A physics degree definitely does contain the exciting elements we had anticipated. The trouble is, there is little or no indication of this in the first year"*
>
> (Henderson, 1998).

It is inevitable that some repetitions from school material will occur in the first year of the university Physics course, and some "boring" topics from the "core" of the course have to be taught, since they provide a theoretical base for the deeper understanding of subject. Henderson (1998) suggests a "remedy" "*to set up a new course of "frontier* *physics", which would be taken along with the main first-year physics courses, and which would contribute perhaps 10-20% of the year assessment.*" There is a divergence of opinion about this suggestion. It has been criticised by some Physics World readers (Agnew, 1998; Giblin, 1998) who are concerned that teaching such courses for the level 1 students, when they are not theoretically prepared to accept and understand the concepts of Physics behind these exciting, but conceptually difficult, topics will lead to producing "*people who could talk eloquently at cocktail parties about the latest superstring theories, but who would be ill-equipped for a world in which they might have to determine the characteristics of a semiconductor, design a vacuum system or calibrate a pyrometer*" (Agnew, 1998).

During the semi-structured interview with students (see Appendix R), they expressed clearly their feelings of dissatisfaction with the rather "dry" university level 1 Physics course of lectures, especially during the first term. It appears that Henderson (1998) has identified an important problem, and expressed the general concern of many first year Physics students. It is a belief that the kind of "frontier" course of lectures which he suggests will not only stimulate interest towards Physics but also provide information about where modern Physicists work today, what are the perspectives and directions of Physics development, what kind of applications modern Physics have in the society and how this may influence our life.

This problem has also been taken seriously by some Universities in the UK, like Imperial College and Reading University, where they provide such "modern" lectures alongside "more prosaic 'core' courses". Although, as it was pointed by Mulheran (1998), lecturer of this course at Reading University "*it is too early to say with confidence that this new course has made a big difference, I can claim some success with the two year groups that have been on the course. Our surveys indicate that most of them are well motivated after their first year and are prepared to put in the hard work once they realise why it is necessary*".

9.2.1.2. Problems associated with tutorials at the level 1 course

The problem with tutorials for some level 1 students seemed to be mainly associated with tutors, as became clear from the interview (See Appendix R). Students' negative attitudes towards tutorials were found to be directly linked to tutors, their level of preparation to teach, ability to meet students' questions and provide them with satisfactory explanations. Some tutors in the level 1 Physics course are postgraduate students with little or no experience of teaching. Moreover, some of them are foreign students who have problems with English.

This is a very typical situation for many universities not only in the UK, but elsewhere, where Physics postgraduate research students are involved in teaching for level 1 undergraduates (Etkina, 1999). Strong support was expressed by science students in the USA universities for a system in which all faculty who regular teach freshman classes should receive professional pedagogical training. *"Faculty who devote time to undergraduate teaching and planning should be given special credit for this in the reward system, and regular opportunities for the enhancement of teaching techniques be offered by institutions."* (Seymour and Hewitt, 1997, p.146). The Teaching and Learning Service (TLS) of the University of Glasgow runs a mandatory workshop for postgraduate students to provide them with basic principles of teaching. The normal duration of the course is three hours. However, it looks like this is insufficient training.

Other aspects of the University of Glasgow Physics course such as:

- level of interest towards laboratory work,
- mathematical level of the course,
- level of the course difficulty and
- demands of the course work

were evaluated similarly by the level 1 and the level 2 students. However, it should be stressed, that even though the level of interest towards laboratory work was found to be statistically not different for both courses, the level 1 students evaluated laboratory as "neither interesting nor uninteresting" with some degree of negative polarisation (see Appendix L, p. 4).

Looking back at the level 1 laboratory practice, level 2 interviewed students noted the big difference between "spoon feeding" and "recipe following" level 1 labs and the more independent level 2 laboratory practice. The set of experiments in level 2 was found to be more interesting than on level 1 as well, although far from being exciting. The possibilities of increasing interest towards and positive outcomes from laboratory practice for Physics course students will be discussed further in the Chapter 11.

9.2.2. Students' perceptions of self in the university Physics course

In the previous section, students' evaluations of external factors such as the course of lectures, laboratories, tutorials, that influence on students' attitudes towards the Physics course and to Physics in general were considered. In this section we will look at students' perceptions of self in the university Physics course. The question is given below:

What are your opinions about University Physics?

I feel I am coping well	☐	☐	☐	☐	☐	☐	I feel I am not coping well
I am not enjoying subject	☐	☐	☐	☐	☐	☐	I am enjoying subject
I found subject is very easy	☐	☐	☐	☐	☐	☐	I found subject is very hard
I am growing intellectually	☐	☐	☐	☐	☐	☐	I am not growing intellectually
I am not obtaining new skills	☐	☐	☐	☐	☐	☐	I am obtaining new skills
I am enjoying practical work	☐	☐	☐	☐	☐	☐	I am not enjoying practical work
I am getting worse at subject	☐	☐	☐	☐	☐	☐	I am getting better at subject
It is definitely "my" subject	☐	☐	☐	☐	☐	☐	I am wasting time in this subject

(see Appendix A, Questionnaire level 1/level 2 97/98, question 11).

Grouping the data and the method of analyses were the same as described before (p.158). Students' responses were compared between:

- Level 1 males and females;
- Level 2 males and females;
- Group I - students planning a degree in Physics and Group II - students not planning a degree in Physics;
- Level 1 and level 2 students;
- Group I and level 2 students;

Graph 9-2 below (p.167) shows the distribution of "positive" responses of students from the above groups. Full data are in the Appendix M, pp. 1-5. Each comparison will be discussed below.

- *Level 1 males and females.*

The only difference in responses of level 1 females and males was found regarding evaluations of students' intellectual growth. More level 1 males than females felt that they experience intellectual growth studying in the Physics course. Females evaluations were rather neutral.

A correlation analysis of students' responses about "*I am growing/not growing intellectually*" with students' evaluations of different factors from Physics school and university Physics experience was performed (using Kendall's *tau_b)*. The data are in the Table 9-2 below, separately for females and males.

Table 9-2: Correlation analysis for the level 1 1997/98 students.

I am growing intellectually/	**Females (N=28)**	**Males (N=87)**
correlates with	*tau_b*	*tau_b*
I liked teacher (at school)	-0.18	0.19*
I liked physics (at school)	0.01	0.28**
Interesting subject (at school)	0.08	0.34**
Easy subject (at school)	0.09	-0.04
Course easy (at the university)	0.46**	0.22*
I feel I am coping well (at the university)	0.61**	0.34**
I am enjoying subject (at the university)	0.52**	0.40**
I am obtaining a lot of new skills (at the university)	0.35*	0.27**
Lectures interesting (at the university)	0.41*	0.46**
Laboratories interesting (at the university)	0.43**	0.22*
It is definitely "my" subject	0.45**	0.34**

* correlation is significant at the 5% level of probability (2-tailed test)
** correlation is significant at the 1% level of probability (2-tailed test)

Note: shaded box marks association different for females and males

Table 9-2 shows several positive significant associations, which were similar for male and female students. However, females who were extremely positive in their evaluations of a school teacher are obviously much less positive about their "intellectual growth " in the university. Situation with male students is different.

Table 9-3 below summarises the associations, which exist between enjoyment of the subject and different factors from the Physics school and university experience. Students' evaluations of their enjoyment of Physics can be considered as a direct manifestation of their attitudes towards the subject.

Table 9-3: Correlation analysis for 1997/98 level 1 females and males.

I am enjoying physics (at the university)	**Females (N=28)**	**Males (N=87)**
correlates with	tau_b	tau_b
I liked teacher (at school)	-0.13	0.20
I liked physics (at school)	0.00	0.32**
Interesting subject (at school)	0.11	0.37**
Easy subject (at school)	-0.06	0.13
Course easy (at the university)	0.13	0.26**
I feel I am coping well (at the university)	0.30	0.44**
I feel I am growing intellectually (at the university)	0.52**	0.40**
I am obtaining a lot of new skills (at the university)	0.36*	0.39**
Lectures interesting (at the university)	0.29	0.53**
Laboratories interesting (at the university)	0.40*	0.24**
Course too mathematical	0.19	-0.07
Work level very demanding (at the university)	0.19	-0.03
It is definitely "my" subject	0.47**	0.42**

* correlation is significant at the 5% level of probability (2-tailed test)
** correlation is significant at the 1% level of probability (2-tailed test)

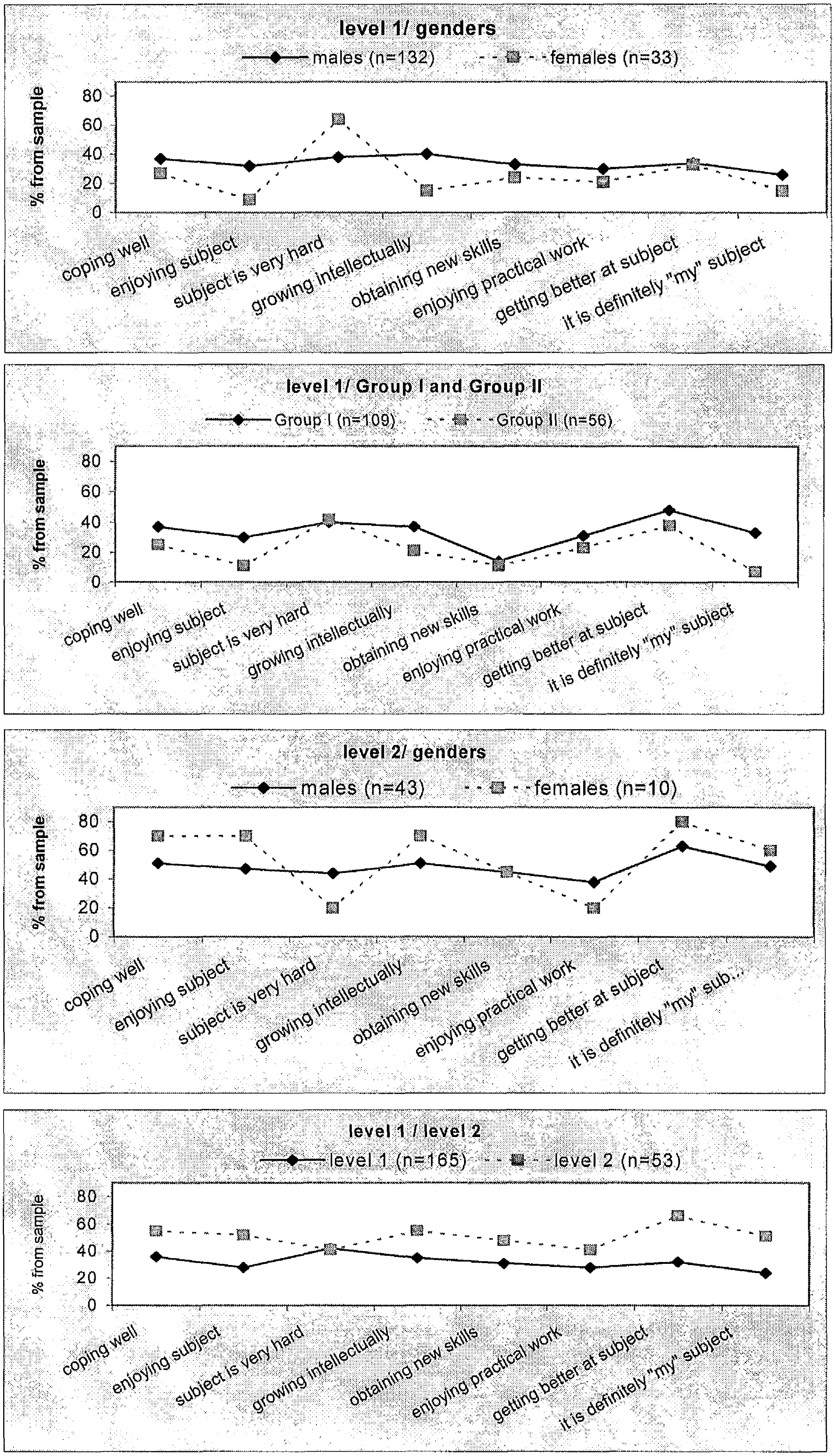
Note: shade marks associations, which are interesting to discuss

It can be seen that those students (both male and female) who were enjoying studying Physics at university found lectures and laboratories interesting and felt that they were growing intellectually, coping with the course and obtaining practical skills. The very strong positive associations exist for females and males between the factor of "*enjoyment of Physics*" and perceptions about Physics as "*definitely 'my' subject*". Once again it was shown that associations between school and university experience in Physics for genders are different.

- *Level 2 males and females.*

No differences were detected between level 2 females and males. Some analyses were impossible due to the small sample of the level 2 females and the strong polarisation of their answers. In general, both level 2 females and males seems to be positive about themselves in university Physics course. (Can it be said that women who

Graph 9-2: Students' perceptions of self in Physics course.



persist in Physics tend to be more independent and self-sufficient than those women who left subject after level 1?). The full data are in Appendix M, p. 3.

- *Group I* - students who were thinking about a degree in Physics and
  Group II - students who were not thinking about a degree in Physics.

Group I students were found to be significantly more positive than Group II students in their evaluations of enjoyment of the subject and practical work as well as in their perceptions of Physics as "definitely 'my' subject". Group I students are more committed to Physics students than students from the Group II and it was expected that their attitudes towards Physics and their perceptions of Physics should be more positive than ones of Group II.

Students from the both groups were found to be similar in their evaluations of their progress in the course, perceived subjects' difficulty, their feelings about intellectual growth and general fillings of improvement in Physics. It looks like the structure of the Physics course stimulates equally well progress and developments of students from the both Groups. Full data can be seen in the Appendix M, p. 2.

- *Level 1 and level 2 students.*

The comparison between the level 1 and level 2 students revealed that there were significant differences in favour of level 2 students, except two cases:

- Physics perceived as a difficult subject by students from both levels and
- Level 1 and level 2 students felt that they were obtaining a lot of new skills in their Physics course.

Because level 2 students are more "selected" and "committed" to Physics than the total level 1 students it is reasonable to expect that they can cope with the course better and enjoy Physics more as well as be more positive about their intellectual growth and improvements in Physics than the total population of the level 1 students. However, results which were obtained when level 2 students were compared to Group I students (those students from the level 1 who were planning about a degree in Physics) were very similar to results obtained when level 2 was compared to the total level 1 students. Table 9-5 shows the results:

Table 9-4: Group I (N=109) and level 2 (N=53) students' perceptions of self in Physics course.

	Positive %	Neutral %	negative %	χ^2	df	Favoured*
	*I feel I am coping well**		*I feel I am not coping well*			
Group I	37	46	17			
Level 2	55	35	10	4.89	2	level 2
	*I am enjoying subject**		*I am not enjoying subject*			
Group I	30	57	13			
Level 2	52	42	6	7.39**	1	level 2
	I found subject is very easy		*I found subject is hard*			
Group I	5	55	40			
Level 2	6	53	41	0.02	1	-
	*I am growing intellectually**		*I am not growing intellectually*			
Group I	37	48	15			
Level 2	55	39	4	5.24*	1	level 2
	*I am obtaining a lot of new skills**		*I am not obtaining a lot of new skills*			
Group I	14	49	37			
Level 2	48	46	6	21.91**	2	level 2
	*I am enjoying practical work**		*I hate practical work*			
Group I	31	48	21			
Level 2	41	51	4	3.84*	1	level 2
	*I am getting better at the subject**		*I am getting worse at the subject*			
Group I	48	46	6			
Level 2	66	33	0	5.01*	1	level 2
	*It is definitely "my" subject**		*I am wasting time in this subject*			
Group I	33	53	14			
Level 2	51	42	7	4.86*	1	level 2

* means significance at 5% level of probability
** means significance at 1% level of probability

Looking back at the results obtained for level 2 and total level 1 students (Appendix M, p.4) two results are interesting to discuss:

1) students' evaluations about enjoyment of Physics;
2) students' evaluations about enjoyment of practical work.

In both cases level 1 students were significantly less positive: level 1 students look like those who were neither enjoying nor disliking Physics, while level 2 students were definitely enjoying the subject. Significantly more level 1 students than level 2 students "hate practical work".

At least one explanation for the latter difference about laboratory practice was found during the semi-structured interview with the level 1 and the level 2 students which took place in May, 1999 (see Appendix R). It was found that the level 1 students were very unhappy about some organisational aspects of the laboratory practice: the system of marking their records and reports. Students had no idea about the reasons for the marks they received due to absence of any feedback and comments. In the previous section 9.2.1, p. 163 it was shown that students from the level 1 and the level 2 evaluated their laboratory practice almost at the same level of interest (although, level 1 students' responses tended to be rather negatively polarised than the responses of the level 2 students, (see Appendix L, p. 4)). However, as happened with the level 1 students, dissatisfaction with the system of marking of students' work can provoke such strong feelings towards laboratory practice as "hate" among some of them.

Intellectual growth is stimulated greatly by the feelings of progress, growing self-confidence in subject. If a student obtains a mark lower than he/she expected without any explanations, depending on the "mood of a demonstrator", the feelings of intellectual growth or satisfaction from the performed work can hardly be expected from such a practice. Spending three hours every week on an activity which gives rise to final disappointment can provoke negative feelings. Feedback in the assessment is very important in helping students to progress and learn from their mistakes. Feedback assists students' ability to think about their work and develops better understanding of the area of study. It gives students a basis for critical thinking and analysing the work done.

The difference in "*enjoyment of Physics*" found between the level 1 and the level 2 students could be partly explained if we look again at the associations shown in the Table 9-4 and at the picture of students' attitudes towards and evaluation themselves in the Physics course (Appendix L, p.4 and Appendix M, p. 4). It was observed that significant positive associations exist between "*enjoyment of Physics*" and interests towards lectures and laboratories as well as feelings of "*intellectual growth in the subject*". The problems related to lectures and laboratories have already been touched. Promote students' intellectual growth looks like very important as well for maintaining students' positive attitudes towards the subject. This was found to be particularly important for female students.

The structure of the Physics course [even without changing its core elements like lectures, laboratories, tutorials] could be built in such a way as to promote and stimulate students' intellectual growth and growth of their confidence in the subject. One of the way is to involve students in *mini-projects* which give students an opportunity to apply their skills and knowledge they gained during their course to solve something real and relevant to our life or/and make something that really applicable. Students doing A-level Physics course (England and Wales) and taking Physics for CSYS are normally involved in different research projects. It has been reported about their success among and positive evaluation by school pupils (Woolnough, 1994). University students also find involvement in real projects stimulating and encouraging (Johnston, 1999; Blundell, 2000). Students who participated in the real-life projects were found to be very enthusiastic, confident, moreover, some of them indicated that *they "have learned more doing this than in the entire physics degree so far*" (Criss Goff, a third-year physics student at Kent University). Participating in real-life projects "*also gives students confidence to know that they can apply their skills and make something that works. This developing confidence in their abilities is the most valuable of the benefits of their participating*" (Hempsel, University of Bristol, 2000).

Since many students expressed disappointment from the repetitions of the material learned at school during the first university Physics term (see Appendix R with interview report) it could be very useful to provide students with some introductory information regarding the general structure of the course at the beginning of the academic year. This introduction would provide students with information about the place of each particular topic in the university Physics course as well as about importance of the "core" courses of lectures in understanding more "exciting" topics. Any new material presented to students is worth considering in the general context of the subject and with respect to students' previous experience and knowledge. Care must be taken in helping students to integrate any new knowledge they obtain about the subject to the previously existing system of knowledge (cognitive system). In this way any new information obtained will be considered as an additional knowledge to the previously existing network. Such an approach will promote the understanding of the subject better and make the picture of the subject fuller and knowledge more meaningful. Moreover, if a chance is given to students to apply and check how this knowledge works, in such a case the feelings of intellectual growth as well as improvements in subject will accompany students' progress. It is a belief, that this approach in teaching will make the learning process more enjoyable and meaningful and will stimulate and promote positive attitudes towards the subject.

9.2.3. Students' opinions about organisation of the Physics course

Students' opinions about organisational aspects of the course were investigated.

Thinking about your Physics course, tick the boxes below to reflect your opinions:

	Strongly agree	Agree	Disagree	Strongly disagree
I found the course well organised	☐	☐	☐	☐
I felt the assessment methods used were good	☐	☐	☐	☐
The time demand was not reasonable for me	☐	☐	☐	☐
I found good support from the academic staff	☐	☐	☐	☐
I think there will be poor career opportunities	☐	☐	☐	☐

A four-point rating scale was used instead of the traditional five-point scale to avoid a neutral category which students tend to choose to avoid making judgements. Students' responses were analysed for each particular statement and compared using a chi-square. The comparison was performed between:

- Level 1 females and males;
- Level 2 females and males;
- Level 1 and level 2 students.

The data from the analyses of students' responses are in the Appendix N, pp.1-3. The following results were obtained:

- *Level 1 males and males*:

No differences were observed. (See Appendix N, p. 1).

- *Level 2 female and male:*

A tendency was observed for level 2 females to look rather pessimistic about their future career prospects (all of the females answered the questionnaire were planning to take Physics for a degree). 90 percent of the level 2 females thought that there will be rather poor career opportunities for them (see Appendix N, p. 2 for full data). The same tendency was observed in other work (Ware and Dill, 1986; Arnold, 1987; Oakes, 1990;) where it was found that, despite good academic performance, females doing science subjects at university experience diminished self-esteem, self-confidence and career ambitions, and these effects were marked strongly among women in science by the second year.

- *Level 1 and level 2:*

Two differences were observed:

Statements	χ^2	***significance***	***favoured***
I found good support from the academic staff	8.62	< 1%	level 2
I think there will be good career opportunities	8.03	< 1%	level 1

Note: df=1; full data are in the Appendix N, p. 3.

Looking back at the Chapter 8, sections 8.10 and 8.11, pp. devoted to investigation of students' expectations from the university Physics course and their fulfillment, the following was found:

preparing for a career	**expected**	**fulfilled**
level 1	51%	25%
level 2	70%	38%

About half of the level 1 students who expected "preparing for a career" from the university Physics course pointed out that their expectations have not been met, only 38 percent of the level 2 students indicated that their expectation about "preparing to career" have been fulfilled.

Physics is not a vocational subject, like engineering, medicine or computer science. That is why early career orientation will be of particular advantage for students. There is a scope for increasing collaboration between the department and the university career services.

However, in general, the organisational aspects of the Physics course and assessment methods used were rated highly by student from the both courses.

9.3. Conclusions

The different factors from the university Physics course and their influence on students' attitudes towards and perceptions of self in university Physics course have been analysed. The following general conclusions can be drawn:

1. Level 1 and level 2 students' attitudes towards "*course of lectures*" and "*usefulness of tutorials*" were different in favour of the level 2 students. Laboratory practice received rather a neutral evaluation by students from both levels with attitudes of the level 1 students being negatively polarised.

2. Level 1 students were found to be significantly less positive than the level 2 students in the evaluations of their:
   - intellectual growth,
   - improvements in subject,
   - enjoyment from practical work,
   - enjoyment of subject in general.

   Supposition

   > "*It can be suggested that the higher the level of pupils studying Physics the more positive attitudes towards Physics these pupils may have, since they tend to be more selected and more dedicated to Physics population than their lower level peers.*"
   >
   > Chapter 6, p.

   is valid when applied to the university Physics students. It was demonstrated that this supposition does not work with school pupils studying Physics: pupils' attitudes were found to be strongly dependent from the context of lessons, where attitudes of self-selected towards Physics S5/S6 pupils were found to be significantly lower than attitudes of younger S4 pupils (see Chapter 6, p. 99).

3. No differences in attitudes towards Physics course were found between females and males from both levels. The only difference between the level 1 females and males was about perceptions of the course difficulty and work load in the course: females found the course more difficult and work level in the course more demanding than the level 1 males.

4. The organisation of the level 1 and the level 2 courses, assessment methods used were rated highly by the level 1 and the level 2 students. However, the level of support from academic staff is perceived as somewhat inadequate for some level 1 students, perhaps reflecting lack of a contact with a teacher they used to have in school.

5. Career perspectives and opportunities considered by the level 2 students are rather low and this is particularly true for females. This is in contradiction to the real situation when people with a degree in Physics are of highly demand not only in research and industry, but in financial sector, commerce, IT (Harris, 2000).

9.4. Practical Recommendations

Following the findings of this Chapter 9, some recommendations, which are believed, will improve students' attitudes towards Physics course and the subject itself, are given below:

1. *Course of lectures*; the traditional "core" structure of the course, although considered as necessary and important, looks a little bit boring and "dry" for some level 1 students. Introduction of an additional, based on "modern" Physics course would be of great interest and importance for orienting in the field of modern Physics and enhancing and mountaineering interest towards Physics in general among first course students.

2. *Laboratories*: Introduction of pre-lab as a theoretical preparation for the laboratory, and post- labs as an activity aimed to consolidate the knowledge and skills obtained from laboratory through solving different kinds of every-day, applied problems, can be recommended for increasing the interest towards laboratory practice, making laboratory more meaningful and beneficial for students. Chapter 11 will be devoted to pre- and post-labs problem and examples of some pre- and post-labs for the first course laboratory practice can be found there.

3. *Tutorials*: It could be recommended to the department to provide additional help to those postgraduate students who are supposed to teach Physics undergraduates.

Courses run by the Teaching and Learning Service (TLS) for postgraduate students provide them with general information about teaching strategies, however some students need a particular information about courses and activities they are likely to be involved in their teaching practice.

4. *Career prospects*: because it was revealed that students perceptions about career prospects for Physicists are rather low, it can be recommended that much more attention needs to be devoted to this aspect by the department. There is lots of information available about career prospects and opportunities for people with a degree in Physics from the University Career Service, some popular periodicals, like e.g. Physics World (Harris, 2000), Internet. The career orientation lectures/seminars can be presented separately through the studying year better by the people credible highly by students, like for example by the Head of the Department or by the Head of the class, or as a part of the "modern" course of Physics providing students with information about their career prospects alongside with information about modern developments and trends in Physics.

5. *Increasing of students self-confidence:* one of the best way to increase students self - confidence in Physics is by giving them more opportunities to apply the knowledge and skills they have got for solving real problems. It can be done as a part of the teaching laboratory practice, which provides students with essential experience in setting up experimental apparatus, collecting and analysing quantitative data, but often lack of creativity. Post-labs can serve this function, providing students with opportunity to apply their skills and knowledge for solving some real-life, every day problems. Chapter 11 will discuss this in the detail. Another way is to involve students in mini-projects. Mini-projects should not necessary be practical projects. It can be an intellectual exercise where group of students could solve a real problem and to compete with another group of students in it. Such kind of mini-projects are in use by the IBLS Department of the university.

6. *Support from the academic staff*: the department should understand the sense and typicality of the discomforts and self-doubts students may experience in the first year of their university course. That is why it would be of great benefit to students if department has a strategy to deal with such kind of problems. Personal advisors, who

will care, guide, express interest, encourage are very important for many students at the early stage of their university life. This is of particular importance for female students who seems experience obvious lack of support they used to have in their school Physics. It is understandable that this is extremely difficult to achieve within university system. However, even possibilities of informal on-line contact with advisor would be a benefit for some students.

Chapter 10

Reasons for students leaving Physics

Analyses of students' attitudes performed in the previous Chapter has not provided the answer to the question "what were the reasons for some students planning a degree in Physics to leave the subject after level 1 of the university Physics course". Therefore, it was decided to look in detail at the attitudes and behaviour of the two groups of the 1997/98 level 1 students:

- those students who were planning to take Physics for a degree at the moment they entered the university Physics course, and who actually entered and passed the level 2 Physics course: we call them *"Committed students"*;
- those students who were planning to take Physics for a degree, but left Physics after the level 1 course: we call them *"Withdrew students"*.

By comparing "Withdrew students" and "Committed students" it was hoped to be able to understand the reasons and illuminate factors which influenced some well-prepared and motivated students to leave Physics. These separate analyses would be helpful in analysing roles of attitudinal, subjective norm and perceived behavioural control factors in predicting students' intentions to study Physics for Honours (Theory of Planned Behaviour, p. 34).

10.1. Methodology

"Committed students" and "Withdrew students" have been extracted from the general pool of the Group I level 1 students [those students who were thinking about a degree in Physics at the moment they entered the Physics Department of the University of Glasgow (see Table 8-6, p.133)].

"Committed students" and "Withdrew students" were compared in the following ways:

- entry qualifications in Physics and Mathematics;

- attitudes towards school Physics;
- expectations from the university Physics course and their fulfilment;
- attitudes towards university Physics course;
- perceptions of self in the university Physics course,
- progress in the course;
- attitudes towards general organisational aspects of the course.

10.2. "Withdrew students" and "Committed students"

"Withdrew students" and "Committed students" were students following the 1997/98 level 1 course and who came to the University of Glasgow with the same intentions of studying Physics for Honours.

In the Table 8-7, p.134 it was shown how 1997/98 level 1 students (those who answered the questionnaire in February, 98 and who were identified) were separated in several groups according to their intentions towards studying Physics. For clarity this Table 8-7 is shown here again:

Table 8-7: Distributions of 1997/98 level 1 students according their intentions to study Physics

Situation in October, 98	Situation in February, 98
"On Level 2 students" (N=76)	13 - not Honours Physics, but opt for level 2 (II B) 3 - not Honours Physics and not for level 2 (II C) 60 - Honours Physics and opt for level 2 (I A)
"Withdrew students" (N=27)	10 - Honours Physics and opt for level 2 (I A) 13 - not sure Honours, but opt for level 2 (I B) 4 - Honours Physics, but opt to leave (I C)
"General students" (N=37)	3 - not Honours Physics, but opt to level II (II A) 34 - not Honours Physics and opt to leave (II C)

Note: symbols in the brackets like (II B) are explained in the Table 8-6, p. 133.

Where

- "*On level 2 students*"- students who entered and passed the level 2 98/99 Physics course;
- "*Withdrew students*" - students who were planning to take Physics for Honours at the beginning of their university Physics course, but who left Physics after the level 1 university Physics course;

- "*General students*"- students who were not going to take Physics for Honours at the beginning of their Physics course and who followed their initial intentions and did not take Physics at level 2.

Two groups of these students were of particular interest (marked by shade in the Table 8-7): "*Withdrew students*" and "*Committed students*" those ones from the I A part of the "On Level 2 students". Students from these two groups had initial intentions to do Honours Physics. However, already shortly after the first exams a large divergence in intentions was observed among "Withdrew students" (see Table 8-7 above):

- only 37 per cent (10, I A) of students were still going to do Honours Physics, while
- 48 per cent (13, I B) became unsure about a degree in Physics, but were planning to study Physics next 98/99 studying year at the level 2, and
- 15 per cent (4, I C) took a decision to withdraw from the Physics department.

What emerged from this analysis is that among "Withdrew students" the signs of uncertainty about Physics as a proposed degree subject were clearly observed already by the beginning of the second Physics module.

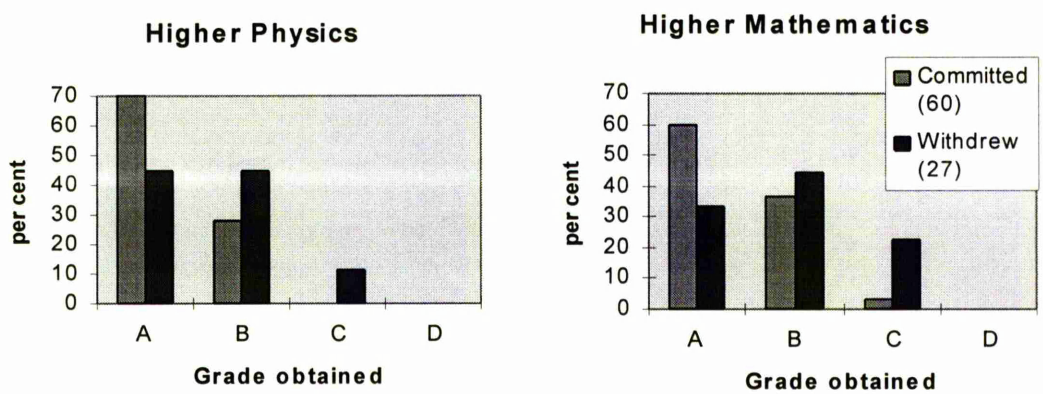
However, in spite of this uncertainty, the majority of "Withdrew students" (85 %) were still going to enter the 98/99 level 2 Physics course. In fact, all of them left the Physics department after the level 1. The factors that might have caused the observed erosion of "Withdrew students" intentions are going to be explored in details in the rest of this Chapter.

Note: Because of the small number of females in "Withdrew" group, the following analyses was performed mainly for "Withdrew students" and "Committed students" in general, avoiding the gender analyses. The ratio of males to females in "Withdrew" group (females (N=9), males (N=18)) was equal to 2, and the ratio of males to females in "Committed" group (females (N=11), males (N= 49)) was equal approximately to 4, indicating that the proportion of leaving females is greater than the proportion of females remaining in Physics. At the beginning of the academic 97/98 year the ratio of males to females planning a degree in Physics was equal approximately to 3 (100/32), see p. 127, Chapter 8).

10.3. Entry qualifications of "Committed" and "Withdrew" students

A comparison analysis of "Committed students" and "Withdrew students" entry qualifications in Physics and Mathematics was performed. The Graph 10-1 below shows the distributions of entry qualifications in Higher Physics and Higher Mathematics separately for "Committed students" and "Withdrew students".

Graph 10-1: Entry qualifications in Physics and Mathematics of "Committed students" and "Withdrew students" (1997/98 studying year).



Statistical analysis (using chi-square) was employed to judge the differences in Higher Mathematics and in Higher Physics entry qualifications of "Committed students" and "Withdrew students". The results of these analyses are shown in the Tables 10-1, 10-2.

Table 10-1: Comparison of "Committed" and "Withdrew" students' grades in Higher Physics.

Higher Physics Grades	A	B+C	χ^2	df	significance	favoured
Committed (N=60)	42 70%	18 30%	5.31	1	< 5%	"Committed"
Withdrew (N=27)	12 44%	15 56%				

It was obtained that "Committed students" entry qualifications in Higher Physics were significantly higher than entry qualifications of "Withdrew students".

Table 10-2: Comparison of "Committed" and "Withdrew" students' grades in Higher Mathematics.

Higher Mathematics Grades	A	B+C	χ^2	df	significance	favoured
Committed (N=60)	36 60%	24 40%	5.17	1	< 5%	"Committed"
Withdrew (N=27)	9 33%	18 67%				

"Committed students" entry qualifications in Higher Mathematics were significantly higher than entry qualifications of "Withdrew students".

In general, it was obtained that the entry qualifications in Higher Physics and in Higher Mathematics of "Committed students" were significantly higher than the entry qualifications of "Withdrew students".

Ability in Mathematics was found to be the best single predictor of students' success in engineering (Seymour and Hewitt, 1997). Correlation analyses (using Kendall's *tau-b*) was performed to look at associations between students' entry qualifications and their progress in Physics exams at university. The Tables 10-3, 10-4 below show the data.

Table 10-3: Correlation analysis of "Withdrew" and "Committed" students' entry grades in Physics with university Physics exams' results.

Higher Physics Grades *correlate with/*	**Committed (N=60)**	**Withdrew (N=27)**
Higher Mathematics Grades	0.51**	0.65**
First term exam results	0.21	0.25
Second term exam results	0.14	0.65**

** means correlation is significant at the 1% (2-tailed)

Table 10-4: Correlation analysis of "Withdrew" and "Committed" students' entry grades in Mathematics with university Physics exams' results.

Higher Mathematics Grades *correlates with/*	**Committed (N=60)**	**Withdrew (N=27)**
Higher Physics Grades	0.51**	0.65**
First term exam results	0.17	0.12
Second term exam results	0.43**	0.51**

** means correlation is significant at the 1% (2-tailed)

The data obtained from these analyses revealed that entry grades in Physics and Mathematics had significant positive associations with "Withdrew students" performance in the second module exams. Following these results it could be expected that the performance of "Withdrew students" in the second module exams would be lower than performance of "Committed students". No association was found between students' entry grades and exam performance in the first module.

10.4. Students' progress in the course

Performance of "Withdrew students" and "Committed students" in the level 1 Physics exams will be compared in this section using average grades obtained by students for the exams. It may have been that "Withdrew students" were simply those who demonstrated inadequate performance in Physics exams and that is why they left Physics because they found their limitations in doing the subject.

Table 10-5: Average exam results for 1997/98 level 1 students.

	"Committed students" males = 49 females =11	**"Withdrew students"** males = 18 females = 9	**"General students"** males = 29 females = 8
First term	2.5 (C)	2.5 (C)	3.5 (D)
Second term	1.8 (B)	3.8 (D)	3.6 (D)

Note 1: since exams results were obtained as Grades the following system was used to convert Grades in numbers: 1-A, 2-B, 3-C, etc..

It can be seen from the Table 10-5 above that the success of "Committed students" and "Withdrew students" in their first term Physics exams was on average the same. However, in spite of it, erosion was observed in "Withdrew students" intentions towards a degree in Physics shortly after the beginning of the second Physics module (see Table 8-7)].

It is worth making some comments about progress of "General students" in Physics exams. In spite of the fact that "General students" had, on average, high entry qualifications in Physics and Mathematics" (see Appendix Q, p. 13) their average Grades for the first term exams in Physics were lower than grades of "Committed students" and "Withdrew students" (Table 10-5). These results can be expected if attitudes of these students towards Physics can be taken in to account: "General students" were not planning to take Physics for a degree and they, probably, did not expend much efforts on Physics as they did towards their proposed degree subject. This neglect was directly reflected in their Physics exams performance. This example can be considered as a good demonstration of how attitudes may influence achievement.

Several possible explanations can be suggested to explain the decline in the "Withdrew students" exams performance:

- *Students ability in Physics and Mathematics*;

It might be that students' progress in the Physics course depended on their entry qualifications in Physics and Mathematics. The weak associations found between students' entry qualifications and first term exams performance can be partly explained by the fact that the Physics term 1 was similar to school Physics course and so no difference would be expected in the performance of students of different abilities in Physics and Mathematics. New work in the term 2 might separate the groups.

- *Erosion of students' attitudes towards Physics;*

Uncertainty demonstrated by "Withdrew students" about their proposed degree subject after the first term exams (in spite of their good performance) revealed that success in the subject alone cannot guarantee its choice as a degree subject. Attitudes towards the subject were found to play very important role in this process.

Attitudes of "Committed" and "Withdrew" students towards university Physics course and their perceptions of self in the course are going to be explored below.

10.5. Students' attitudes towards university Physics

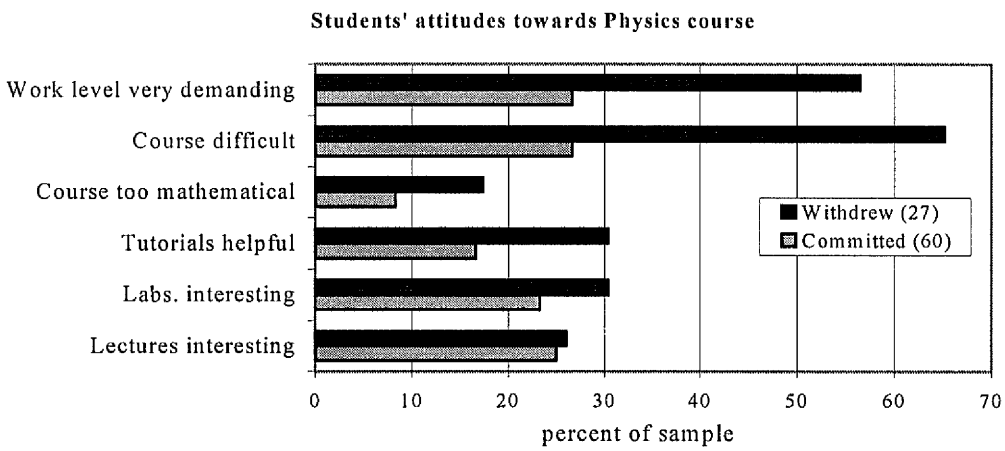
The previous analyses of students' attitudes has shown that, while students at level 1 tended to hold positive views about the organisational aspects of the course, they indicated a number of areas where attitudes tended to be less positive. These areas are going to be explored in details and separately for "Committed students" and "Withdrew students".

10.5.1. Students' attitudes towards the university Physics course

Example of the question was given in the Chapter 9, p. 158, or can be seen from the Appendix A, Questionnaire 97/98 level 1/level 2 question 12. The same method of grouping and analyse was applied as described before (Chapter 9, p. 158). Method of chi-square statistic was employed to test for significance between "Committed students" and "Withdrew students" responses.

The bar chart below represents the distribution of frequencies of "Committed students" and "Withdrew students" positive responses on this question.

Graph 10-1: Students' attitudes towards university Physics course (%).



Despite the appearance of differences between the two groups, only two statistically significant differences emerged between "Committed" and "Withdrew" students: perceptions of the course difficulty and work load in the course. In both cases "Committed students" were significantly more positive than "Withdrew students": "Committed students" evaluated the level of the course difficulty as rather neutral one - neither very difficult nor very easy, with some degree of polarisation towards difficult, while "Withdrew students" viewed the course as a difficult one. Work level in the course was evaluated by "Committed students" as rather neutral, with some tendency towards the demanding one, while "Withdrew students" perceived the work level in the course as very demanding one (see Appendix Q, p.6).

It is worth to point out that "Withdrew students" were positive about course of lectures and laboratories and found tutorials helpful. (Appendix Q, p. 6).

"*Perceived difficulty of the course*" and "*work load in the course*" were found to be related to control beliefs which pupils normally have about enrolling in Physics at school (Crawley and Black, 1992). Control beliefs form a perceived behavioural control factor *(PBC)* of the behaviour, which has a direct influence on a person's intentions to behave (Theory of Planned Behaviour, p.34). Control beliefs are associated with factors, which may facilitate or obstruct a student's engagement in the behaviour (e.g. studying Physics for Honours). Taking into account obtained results it appeared that *PBC* factor of the behaviour *studying Physics for Honour* for "Withdrew students" was lower than *PBC* factor for "Committed students" already shortly after the beginning of the second university term.

If attitudes towards course of lectures, laboratories and tutorials are considered as components of the attitude towards studying Physics for Honours (*AB*) than it can be seen that attitudes of students from both groups were similar (Graph 10-4 and Appendix Q, p.6). "Withdrew" and "Committed" students' attitudes towards the course in terms of the assessment methods used, time demand, support from the academic staff, general organisation of the course were found to be similar as well (see Appendix Q, p.8)

To add some more components to the picture of students' attitudes towards the behaviour (*AB*) and general picture of the behavioural intentions (*BI*) (see equation 3.5, The Theory of Planned Behaviour), "Withdrew students" and "Committed students" perceptions of self in the Physics course were analysed and compared.

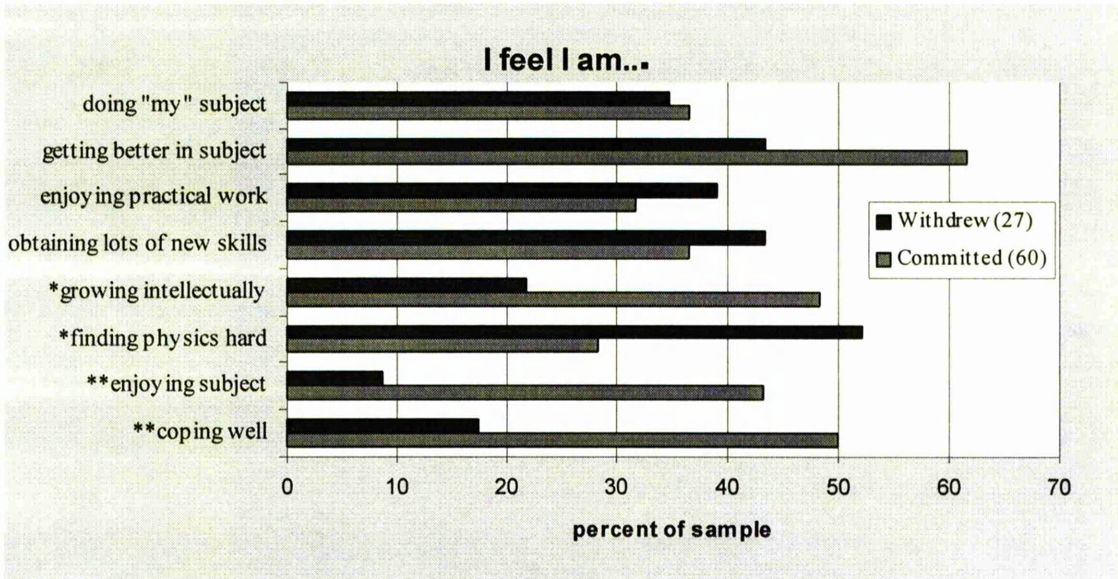
10.5.2. Students' perceptions of self in the university Physics

The example of the question was given in the Chapter 9, p.164 or can be seen in the Appendix A, questionnaire 97/98 level 1/level 2, question 11). The same method of analyses was employed as described in the previous section.

The bar chart below shows the distribution of frequencies of "Committed students" and "Withdrew students" positive responses on this question. A single (*) and double star

(**) indicates the statements where "Committed" and "Withdrew" students' responses were statistically different: one star (*) indicates significance at 5%, double star (**) indicates significance at 1% (Appendix Q, p.7).

Graph 10-2: Students' perceptions of self in university Physics course (%).



Four cases were revealed where perceptions of self in Physics course of "Committed students" were found to be significantly different from perceptions of "Withdrew students". In spite of the fact that "Withdrew students" performance in the first term Physics exams was as good as performance of "Committed" students (see Table 10-7), it was observed that shortly after it "Withdrew students" demonstrated that they felt themselves significantly less positive in the Physics course than "Committed students". General attitudes of "Withdrew students" towards Physics (expressed through "*I am enjoying Physics*") were also significantly less positive than attitudes of "Committed students".

Looking at these results and applying them to the Theory of Planned Behaviour, it can be seen that already shortly after the first term exams behavioural intentions towards studying Physics for Honour of "Withdrew students" were much weaker than intentions of "Committed students" (perceived behavioural control (*PBC*) [*difficulty of the course* and *work load in the course*] and attitude towards behaviour (*AB*) [*enjoyment of Physics*] of "Withdrew students" were significantly lower than of "Committed students"). Observed large divergence in "Withdrew students" intentions towards a degree in Physics when 65 per cent of them became unsure about their proposed degree in

Physics shortly after the first term exams (see Table 8-7) can be considered as a direct manifestation of this qualitative analysis.

It was decided to perform a correlation analyses to find out what kind of associations exist between students' enjoyment of Physics and other factors from their university and school Physics courses (using Kendall's *tau-b)*. These might provide insight into the factors that were contributing to enjoyment of the subject. The results are in the Table 10-6 below (full data are in the Appendix K, pp.2-3):

Table 10-6: Correlation analysis for "Withdrew" and "Committed" students.

I am enjoying Physics (at the university)	**"Committed" (N=60)**	**"Withdrew" (N=27)**
correlates with	*tau_b*	*tau_b*
I liked teacher (at school)	0.25*	-0.11
I liked physics (at school)	0.27*	0.14
Interesting subject (at school)	0.19	0.42*
Easy subject (at school)	0.11	0.13
Course easy (at the university)	0.21	0.18
I feel I am coping well (at the university)	0.41**	0.36*
I feel I am growing intellectually (at the university)	0.50**	0.52**
I am obtaining a lot of new skills (at the university)	0.53**	0.37*
Lectures interesting (at the university)	0.55**	0.55**
Laboratories interesting (at the university)	0.39**	0.22
Course too mathematical	0.07	-0.025
Work level very demanding (at the university)	-0.01	0.11
It is definitely "my" subject	0.39**	0.33*

* correlation is significant at the 5% level of probability (2-tailed test)
** correlation is significant at the 1% level of probability (2-tailed test)

Note: shaded boxes mark association which are interesting to discuss

Looking at the results it follows that students (both "Withdrew" and "Committed") who were enjoying Physics were those who:

- felt that they were coping with the course well and were growing intellectually;
- found lectures and laboratories interesting and were obtaining a lot of new skills.

It was found from the previous section analysis that "Withdrew students" attitudes towards university course of lectures and laboratories were not different from attitudes of "Committed students", and "Withdrew students" had feelings about obtaining new skills similar to those of "Committed students". That is why the last three factors (interest towards lectures and laboratories, and obtaining new skills) cannot be playing any significantly different roles on "Withdrew" and "Committed" students' attitudes towards university Physics. The differences between "Committed students" and "Withdrew students" were in their evaluations of their cope with the course and of perceived intellectual growth: "Committed students" were significantly more positive about themselves about their ability to cope with and their intellectual growth at the course than "Withdrew students".

In general what has been revealed (from the comparison analyses of "Withdrew students" and "Committed students" perceptions of self in the Physics course) is that shortly after the beginning of the second university term perceptions of self of less well qualified "Withdrew students" were significantly lower perceptions of students of better qualifications from "Committed" group, in spite of the similar performance in the first module exams. This analysis has added another "negative" component to the general picture of the behavioural intentions of "Withdrew students" towards a degree in Physics – the attitudinal one. After this, behavioural intentions towards a degree in Physics of "Withdrew students" became much weaker than intentions of "Committed students" (The Theory of Planned Behaviour). Following these results it could be predicted that exams performance might drop off for "Withdrew students" in the next term (taking into account the attitude-achievement influence). If this happened "Withdrew students" would have almost no beliefs in favour of their further engagement into Physics and this would likely drive them to withdraw from Physics. That was what actually observed.

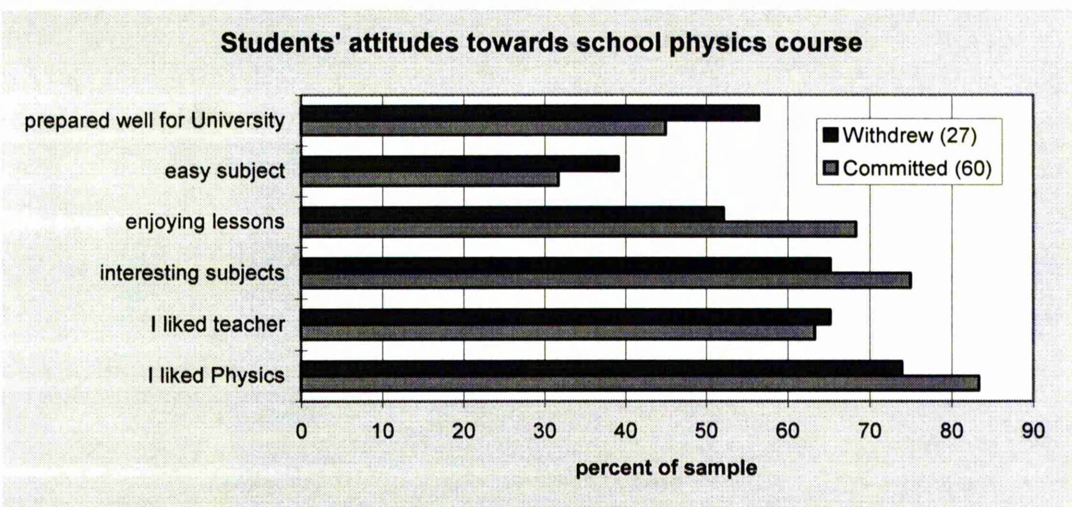
The question is: why "Withdrew students" perceptions of self in the Physics course first term were relatively low? Was this because they did not have enough skills and abilities to perform well and felt themselves uncomfortable being in the group with more prepared and able peers, or because they did not have someone nearby who could tell them about their performance, i.e. inability to judge adequately their progress? These questions are difficult to answer on the base of the gathered data. It was a hope that separate analysis of these students' attitudes towards school Physics, factors influenced their choice of Physics for Honours, expectations from and their fulfilment by the Physics course could help to find out answers on the above questions.

10.6. Students' attitudes towards school Physics course

In this section the effect of attitudes towards Physics developed by students during their school years was investigated and compared for "Withdrew students" and "Committed students". The example of the question was given in the Chapter 8, p. or can be seen in the Appendix A, questionnaire level 1/level 2 97/98, question 10. Exactly the same method of grouping and analysing the data was used as described in the Chapter 8, p. 135 (where students' attitudes towards school Physics were investigated).

Graph 10-3 below shows the distribution of "Committed students " and "Withdrew students" positive responses on this question.

Graph 10-3: Students' attitudes towards school Physics course



Although some "differences" in "Committed" and "Withdrew" students' attitudes can be seen from the Graph 10-3, statistically these students were similar in evaluations of their school Physics experience. Students from both groups

- liked Physics at school and found lessons interesting and enjoyable;
- liked the teacher and felt that they were rather well prepared at school for university Physics.

Taking into account the high entry qualifications of "Committed students" and "Withdrew students" in Physics and Mathematics and their positive attitudes towards Physics at school, their decisions to study Physics at the university for a degree can be explained (in the frame of the Theory of Planned Behaviour). However, can school be responsible for the "Withdrew" students' failure to be happy and successful in university Physics course?

In much work conducted at schools it was found that the role of the teacher is the critical one in developing interest towards Physics, making it attractive and interesting for pupils (Coulson, 1992; Woolnough, 1994; Seymour and Hewitt, 1997). Teachers who are personally interested in the subject and enthusiastic about it are able to excite and promote their subject, and very often they become the primary inspiration for their students' positive attitudes towards studying it further. There is some element of danger in this, in that, for some students, their interests in the subject can be based largely on the enthusiasm of their school teacher, or they may be over-dependent on their teachers' personal encouragement. Such students can be at risk of discovering their lack of enjoyment of Physics only at university where there is a different environment and different teacher-student relationships. Some students being over excited by Physics at school can also suffer from the lack of necessary study skills, habits, disciplines needed for university level of work.

Correlation analysis (using Kendall's *tau-b* statistics) was performed to see how the factor "*I liked the teacher*" associates with such factors as interest towards lessons, level of difficulty of lessons, attitudes towards university Physics course, etc.. The data are shown in the Table 10-7 below.

Table 10-7: Correlation analysis for "Committed" and "Withdrew" students

I liked the teacher/	**"Committed" (N=60)**	**"Withdrew" (N=27)**
correlated with	*tau_b*	*tau_b*
I liked physics (at school)	0.74**	0.50**
Interesting subject (at school)	0.62**	0.40*
Easy subject (at school)	0.22*	0.19
Course easy (at university)	0.11	-0.30
I am obtaining a lot of new skills (at the university)	0.23*	0.26
Laboratories interesting	-0.01	-0.03
Lecturers interesting (at the university)	0.16	0.08
I am growing intellectually (at the university)	0.20	-0.03
I am enjoying subject (at the university)	0.25*	-0.12

* correlation is significant at 5% level (2-tailed test)
** correlation is significant at 1% level (2-tailed test)
Note: The associations, which are interesting to discuss, are marked by shading in the Table.

The marked difference between "Withdrew students" and "Committed students" was found regarding students' associations of the teacher with enjoyment of Physics at the university. For "Committed students" these associations were significant and positive, while for "Withdrew students" these associations were negative (however, there is a possibility that associations could be significant if a larger sample of students were considered, Clegg, 1997, p. 182). For students from both groups the teacher has strong significant positive associations with students' positive experience in Physics at school.

Analyses of students' attitudes towards Physics at school have revealed no difference between "Committed students" and "Withdrew students". However, associations of the teacher and students' attitudes towards university Physics were of different polarity. The last observations indicate that some "Withdrew students" who liked the teacher at school were not enjoying doing Physics at the university, while for "Committed students" these associations were positive. It appeared that the role of the teacher was different in forming "Withdrew students" and "Committed students" attitudes towards Physics. Observed strong positive associations of the teacher with students' positive attitudes towards and interests in Physics at school make it reasonable to assume that the lack of the contact with the school teacher at the university may influence "Withdrew students" attitudes towards Physics negatively.

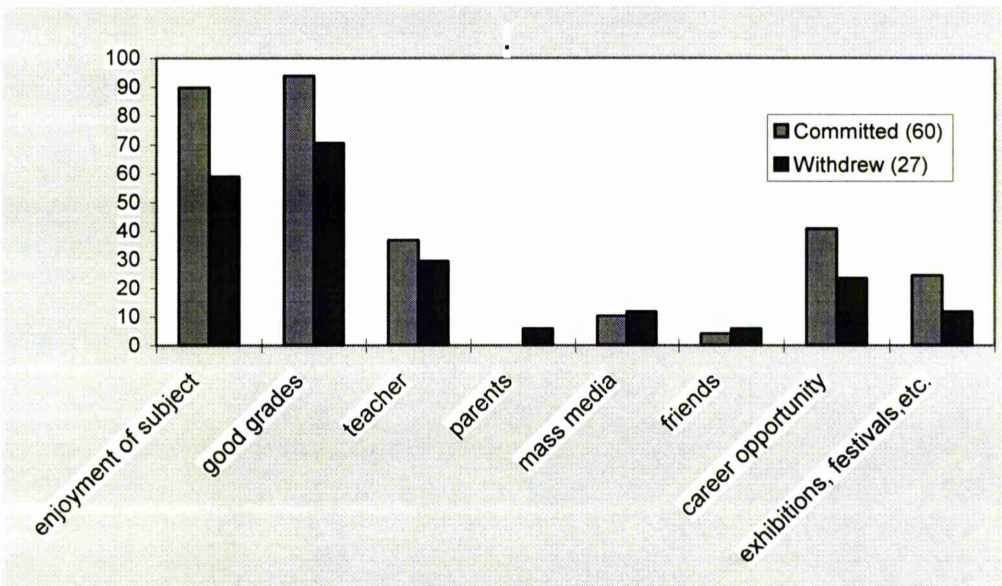
10.7. Factors influencing choice of Physics for Honours

It is a general concern to understand the reasons attracting students into Physics in order to evaluate:

1) which of them make students' persistence in Physics more likely, and
2) which hold up less well during the first year of the university Physics course.

That is why it was decided to look again at factors influencing "Withdrew students" and "Committed students" choice of Physics for Honours (example of the question is in Chapter 8, p. 140). The Graph 10-4 below shows the frequency distribution of the students' responses.

Graph 10-4: Factor(s) influencing students' choice of Physics for Honours (%).



Two significant differences have emerged from the comparison analyses (Graph 10-4) in favour of "Committed students": "*enjoyment of subject at school*" and "*good grades in Physics at school*" were significantly more important factors for "Committed students" than for "Withdrew students" in their choice of Physics for Honours (see Appendix Q, p. 2). In general, the same four main factors have emerged for these students as from the analyses done in the previous Chapter (regarding level 1 and level 2 students in general) with response rate higher than 20 per cent: *good grades in Physics at school, enjoyment of Physics at school, teacher at school, likely career opportunities.* The first two factors were significantly more important than the last two for both groups of students.

In a research study conducted over three-year period (1990-1993) with 335 students doing Science, Mathematics or Engineering major (S.M.E) at seven four-year institutions of different types and locations in USA it was found that *"the best foundation for survival and success [in S.M.E. major] is to have chosen major because of the intrinsic interest in the discipline and/or in the career field to which it is leading"* (Seymour and Hewitt, 1997).

In the same work it was observed that among students who left S.M.E. major, the notable reasons for leaving were:

- active influence of others in students' choice of Honours subject;
- confusion of good grades with interest and aptitude for science and science-based career.

Active influence of others was found to be one of the most significant reasons for American students to study science-related subject(s) for a degree. Much of this influence came from the family members, especially for those students whose parents were financing their undergraduate education. The role of parents on Scottish students' decisions to study Physics and other science-related subjects for Honours was found to be negligibly low especially for "Committed students" (see Graph 10-5 and Appendix Q, p. 2). It is interesting to point out that the experimental group of students participating in the present research study entered the university just a year before the tuition fee was introduced in Britain. Would this innovation change the value of parents' influence on their children's choice of the Honours subject(s)?

> Following the observations of Seymour and Hewitt (1997) it can be suggested that "Withdrew students" (as well as "Committed students), who had come to the decisions to take Physics for Honours mainly because of the interests and enjoyment in Physics plus their ability to do the subject, had a strong initial potential for surviving in Physics. However, this potential was much stronger for "Committed students" than for "Withdrew students", because almost 9 in 10 "Committed students" indicated the both factors (enjoyment of Physics and good grades in it) while only 6 out of 10 "Withdrew students" indicated "enjoyment of subject" and 7 out of 10 indicated "good grades" in it as factors determining their choice of Physics for a degree. It looks like to feel good at the subject at the university two factors ("*enjoyment of Physics*" and "*good grades in Physics at school*") should be present together and determine the intentions to take the subject for Honours.

10.8. "Expectation versus reality" conflict?

From the analyses performed with level 1 and level 2 students in Chapter 8 it was found that the highest expectations of students about "*deeper understanding of subject*", "*experiencing intellectual growth*" and "*preparing for a career*" have not been met fully by the Department. The so-called "expectation versus reality conflict" may influence negatively some students' attitudes towards university Physics and studying the subject for a degree. That is why it was decided to perform the separate analyses of "Committed students" and "Withdrew students" expectations from the university Physics course and the degree these expectations have been met.

10.8.1. Students' expectations from the university Physics course

Example of the question was shown in the Chapter 8, p. 145 and can be seen in the Appendix A, questionnaire level 1/level 2 (97/98), question 8.

The method of analysis of students' responses was exactly the same as described before (see Chapter 8, section 8.10.1, p.145). Students' expectations from the university Physics course were compared (using chi-square) between:

- "Withdrew students" and "Committed students";
- "Withdrew students" and the level 2 students;
- "Committed students" and the level 2 students.

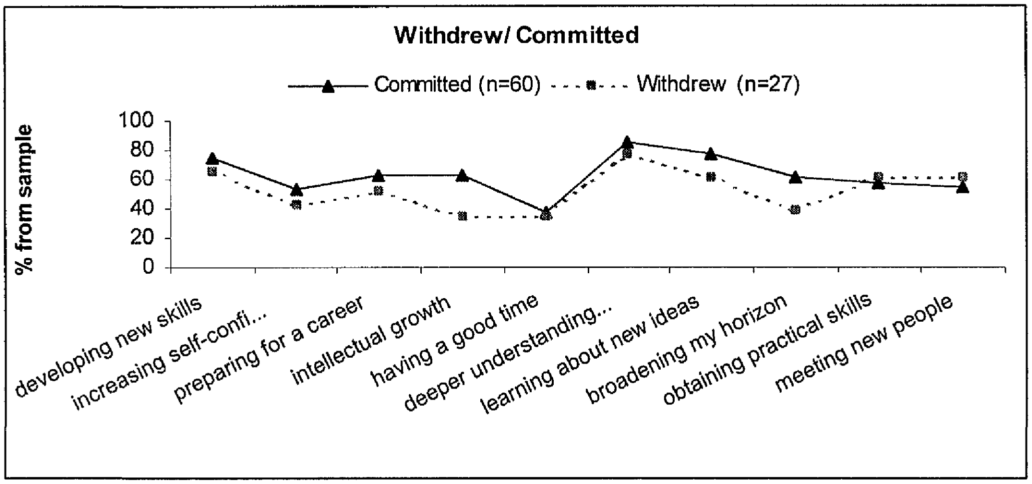
Graph 10-6 below shows the distribution of expectations for these groups of students. The full data are in the Appendix Q, p. 3.

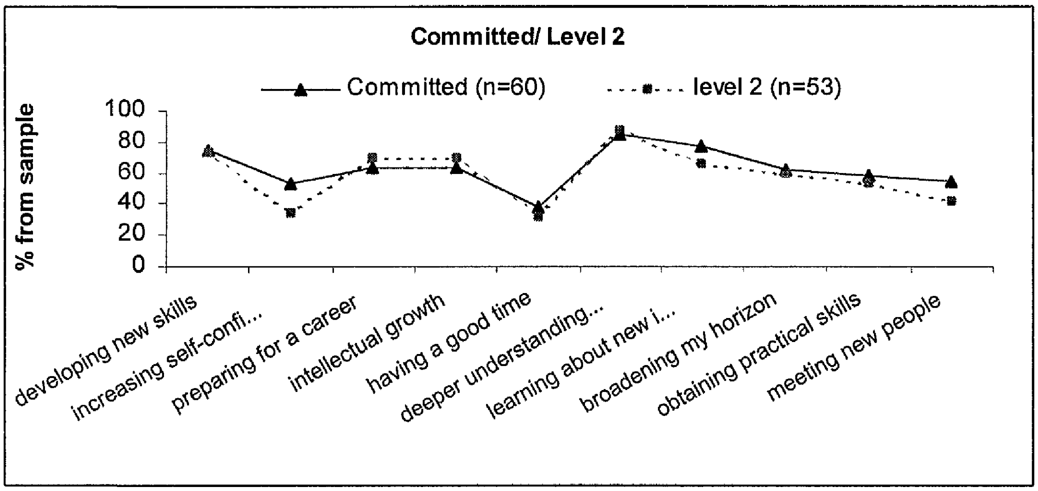
The following results were obtained:

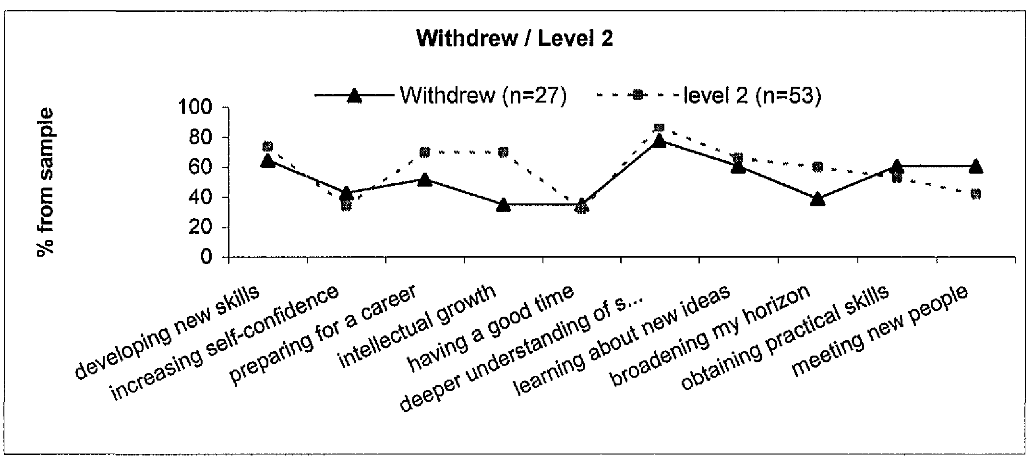
- *"Withdrew students" and "Committed students";*

Expectations of "Committed students" about "*experiencing intellectual growth*" were found to be significantly higher than expectations of "Withdrew students". In the rest of the expectations (nine out of ten) "Committed students" and "Withdrew students" were similar. (Full data are in the Appendix Q, p. 3).

Graph 10-5: Students' expectations from the university Physics course







- *"Withdrew students" and the level 2 students;*

Only one difference was found: the level 2 students expectations were significantly higher "Withdrew" students' expectations regarding "*experiencing intellectual growth*". No other differences were found. (See Appendix Q, p.3 for full data).

- *"Committed students" and the level 2 students;*

One difference was observed:

expectations	χ^2	*significance*	*favoured*
increasing my self-confidence in Physics	4.1	< 5%	"Committed"

"Committed students" expectations about "*experiencing intellectual growth*" were similar to expectations of the level 2 students (96 per cent of the level 2 students identified Physics as their degree subject). Looking at the picture of expectations of "Committed students" and "Withdrew students" and comparing it to the picture obtained for the level 1 females and males (see section 8.10.1, p.146) it can be seen that the same difference as between "Committed students" and "Withdrew students" expectations about "*experiencing intellectual growth*" exist between the level 1 females and males' expectations in favour of males. [It may be that the ratio of 4 to 1 in favour of males in "Committed" group makes the patterns of their expectations close to the patterns obtained for the level 1 males, and the ratio 2 to 1 in favour of males in "Withdrew" groups allow females' expectations to have a significant impact on the whole picture of results for this group].

In general, the expectations of "Withdrew students" and "Committed students" from the university Physics course were very similar. Only one difference was revealed in expectations about "*experiencing intellectual growth*". This exception makes expectations of "Committed students" closer to the expectations of the self-selected towards Physics level 2 students (on the level 2 the ratio of males to females was approximately 4 to 1 as well as for "Committed students").

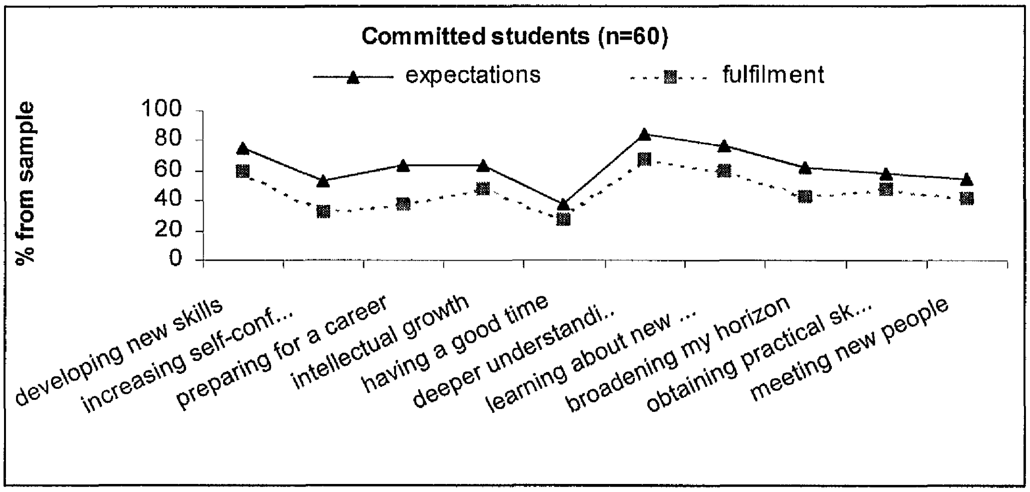
10.8.2. Fulfilment of students' expectations from the Physics course

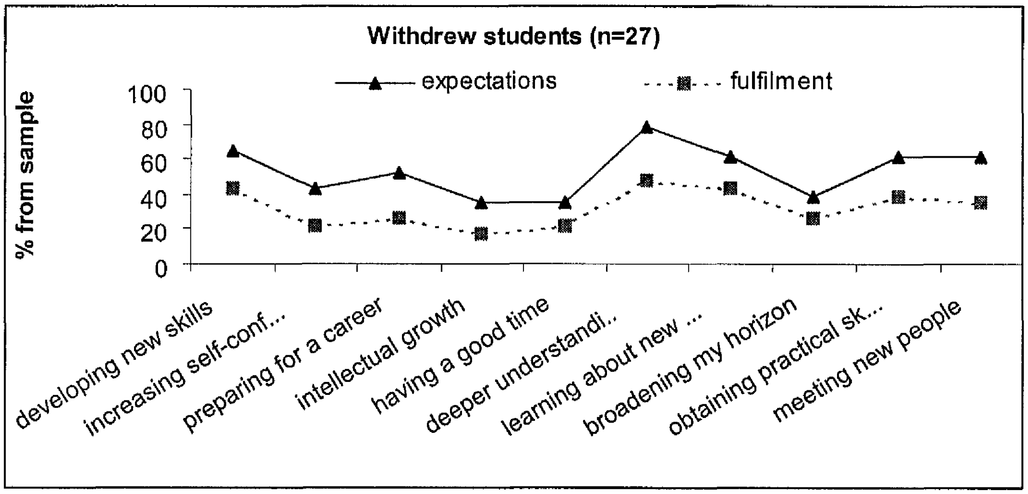
To check how students' expectations have been met, a comparison analysis was performed between students' expectations and the fulfilment of these expectations. A significant difference will indicate which of the expectations have not been met so far. Comparison of expectations and their fulfilment was carried out for:

- "Committed students";
- "Withdrew students".

Results are in the Appendix Q, p. 4. Graph 10-6 shows the distribution of the data.

Graph 10-6: Fulfilment of students' expectations.





The following results have emerged from the analysis performed:

- *"Committed students";*

Only half (five out of ten) suggested expectations were identified as fulfilled by "Committed students". Full data about this analysis are in the Appendix Q, p. 4.

- *"Withdrew students";*

From the analysis performed it was obtained that most expectations (eight out of ten) of "Withdrew students" have been met by the Physics department already by February, 98. The data can be seen in the Appendix Q, p.4.

Although the statistical analyses suggest that the "Withdrew students" were more satisfied than the "Committed students", scrutiny of the graphs 10-7 shows that this is largely an effect of the different sample sizes. These two groups tended to follow the same pattern.

10.9. Discussions and recommendations

In order to explain the reasons why students, who had planned to do a degree in Physics left the subject after one year of university experience, a comparison analysis was performed between:

- "Withdrew students", those students who were planning a degree in Physics at the moment they entered the university Physics course (October, 97), but who left Physics after the 1997/98 level 1, and
- "Committed students", those students who planned to take Physics for a degree at the university (October, 97), and who entered and passed the 1998/99 level 2 Physics course.

The following facts have emerged:

1. "Committed students" appeared to be better qualified in Physics and Mathematics at school than "Withdrew students".

2. Significantly more "Committed students" than "Withdrew students" made their choice of Physics as a degree subject based on two factors: their enjoyment of the subject at school and good grades in it.

3. "Withdrew students" perceived the Physics course at the university as significantly more difficult and work level as significantly more demanding than "Committed students".

4. Students from both groups had similar results in the first term Physics exams. However, shortly after the beginning of the second Physics term "Withdrew students" revealed that they felt themselves to be coping with the course significantly less well and to be developing intellectually significantly less well than "Committed students". Attitudes towards Physics of "Withdrew students" were significantly lower than attitudes of "Committed students" already in February.

5. A decline in the term 2 exam performance was observed for "Withdrew students" while improvement was observed in the performance of the "Committed students".

6. There was no difference between groups in their evaluation of the course of lectures, laboratories and tutorial.

In general, it is possible to conclude that one of the main reasons for "Withdrew students" to withdraw from Physics can be in students' low level of enjoyment of the subject at the university and low level of perceptions of self in it. These feelings might have been generated partly by

- "Withdrew students" lower entry qualifications in Physics and Mathematics;
- lack of self confidence and feelings of inadequacy.

It might have been that these factors caused problems to "Withdrew students" who performed in the first term exams similar to "Committed students", but, who felt significantly less positive in the course and enjoyed Physics significantly less than "Committed students". Inability to obtain adequate evaluation of their progress and problems might have made some of them feel uncomfortable in the course. A low level of enjoyment and self-confidence could have generated some doubts when students became unsure about their adequacy to cope with Physics as their degree subject and so they became unsure about what to do next. This situation would be expected to influence students' grades adversely.

Following these observations, it looks like the system of the Physics department acts in such a way as to keep only the *most* able and better prepared students and assists less able students to find their limitations in the subject and leave it. Looking at the data represented in the Appendix Q, pp.10-12, it can be seen that students with entry grade "C" in Physics or/and Mathematics have almost no chance of surviving in Physics. It can be clearly seen from the Appendix Q, pp.10-12 that students who persist in Physics have almost exclusively A and B entry grades in Physics and Mathematics.
Three factors have emerged, which if present all together may guarantee students' success in the university Physics course and in Physics and which may be used to predict students' persistence in Physics:

1. enjoyment of and interest in Physics at school;
2. entry grades in Physics and Mathematics higher than C;
3. self-confidence and self-esteem.

If these three factors are present, a student will be likely to survive well in the university Physics. However, if a student planning a degree in Physics demonstrates a lack of any of these factors, he/she may experience problems in the Physics course.

If withdrawal is considered a problem, and if the department would be interested in keeping more students in Physics, some remedial arrangements could be recommended to help these students to adapt to the university system and, probably, to fulfil their Physics aspirations:

- Probably an alternative course of Physics, more simple, with an additional relevant mathematical course would be a good idea (at least for the first year) to help these students to get used to being in the university system.

- The course of lectures and laboratories should be more appealing to students' aspirations from, and interests in, Physics. This is particularly important for the first term of the level 1 Physics course. "Dry" and "repetitious" course of lectures and rather boring laboratory practice can hardly motivate students to cope with perceived course difficulty and work load. Another subject, which may be not so demanding, can become more attractive than Physics.

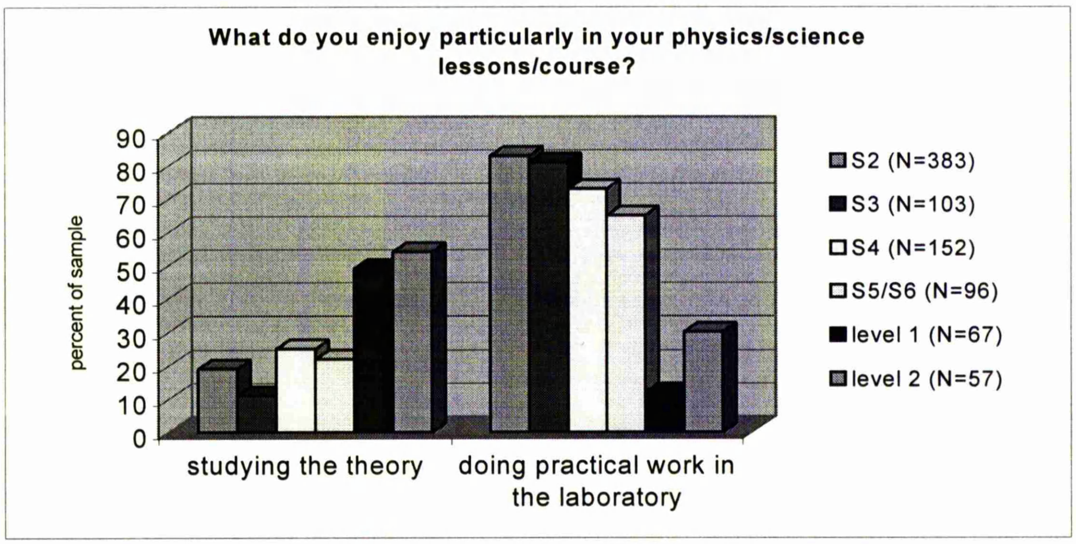
- Adequate support from a curriculum supervisor, who would be interested in students' progress, be motivating and encouraging for students and be able to give some practical advice about how to organise students' work and how to handle the work load. [The loss of a regular contact with the high school teacher who encouraged students to believe in their ability to do Physics was found to be very critical for students' self-confidence (Seymour, Hewitt, 1997)]. It is very important for students to understand that the problems they experience are common to others at the early stage of university course. They also need some help in deciding whether their problems can be overcome or whether they indicate a need to rethink their career plans.

Chapter 11

Pre- and post-labs in laboratory practice

In this Chapter, one of the ways of improving level 1 Physics laboratory practice will be discussed. From the data obtained in this research study it was revealed that the popularity of laboratory work in the university Physics course is much lower than it is in school Physics and Science lessons (Graph 11-1 below). A general decline of the popularity of laboratory work was observed as pupils grow older (see Graphs 7-3 and 7-4). However, it can be clearly seen from the Graph 11-1 that perceptions of laboratory work by the level 1 Physics students are particularly poor even in comparison to the ones of the level 2 students.

Graph 11-1: Most and least enjoyable activities in Science/Physics lessons relative to the university Physics course



At school "doing laboratory practice" was found to be the most enjoyable activity at any level at secondary schooling (graphs 7-3, 7-4), but at the university this activity was one of the least enjoyable (see Appendix F, p.9-10). The high popularity of laboratory work at school might be partly due to pupils' dislike of "learning the theory" (see Graph 11-

1) where the practical work can be considered as a more attractive alternative (Woolnough, 1996). However one of the main reasons for the success of the school laboratory practice seems to be in the structure of the school Science/Physics course where laboratory work is integrated with theory. This is almost impossible to achieve at university level. In a university Physics course, because of limited equipment and facilities and due to large number of students who are supposed to work with it, it is very often the case that students perform laboratory work unrelated to their main course often either before or after the topic was introduced to them. It has been revealed that students often have few ideas about links between an investigation they carry out and their current science work (Berry et al, 1999) and students often fail to relate the laboratory work to other aspects of their learning (Hodson, 1993).

It is unlikely that the low popularity of laboratory work at level 1 was responsible directly for the loss of Physics students. Laboratory practice was equally popular with those who stayed in Physics ("Committed students") and with those who left Physics after level 1 ("Withdrew students"), see Appendix Q, pp.6-7. However, it has already been discussed that attitudes towards laboratory practice and attitudes towards Physics itself are strongly correlated (see Table 9-4). This confirms work by Hofstein *et al.* (1976) and Raghubir (1979).

Interviews with level 1 and level 2 Physics students were used as opportunities to seek students' opinions about their laboratory practice and ways of improving it. Based on a previous work (Johnstone *et al*, 1994; Johnstone *et al*, 1998) two ways that may help laboratory to become work better were considered: pre-lab which aims to prepare the mind of a learner for the lab before it starts and post-lab, which aimed to help a student to extend and consolidate the knowledge and skills obtained from the lab. Pre-labs and post-labs were written that fit the entire first term Physics laboratory course.

11.1 Role of laboratory in teaching Physics

According to Ausubel (1968) the laboratory "*gives the students the appreciation of the spirit and methods of science, ... promotes problem-solving, analytic and generalisation ability... provides students with some understanding of science*" . Shulman and Tamir (1973) put objectives of laboratory practice into five groups: skills, concepts, cognitive abilities, understanding the nature of science, and attitudes. In actual practice, laboratories are achieving only a few of these objectives. Hodson (1993) points out that the priorities teachers give to aims of laboratory practice affects how they operate in the laboratory, and it is highly probable that differences among laboratory expectations affect learning outcomes (Hofstein and Lunetta, 1982).

The main objectives of the level 1 Physics laboratory practice are mainly focused on developing experimental skills (*use of variety of Physics apparatus, gathering data, and their interpretation and analyses)* and skills in writing a laboratory report (Level 1 Laboratory Manual, 1999-2000).

A Laboratory Manual is provided for every level 1 Physics student at the beginning of an academic year. Aims and objectives of each experiment are stated. Each experiment is clearly defined and instructions are given on how to handle measurements and what kind of results should be obtained. This kind of laboratory practice can be described as *closed investigations* (Berry *et al*, 1999) where the aim and each step of the task is highly specified by a procedure given to student in the Manual. It appears that this is a very typical way of conducting laboratory practice in first year university science courses (Johnstone *et al*, 1994; White, 1996; Bennett and O'Neale, 1998) and it has been critisised for its "*lack of active participation [of students] in experimental design*" (Bennett and O'Neale, 1998) and its limitations where students are trained to follow directions rather than conducting investigations (White *et al.*, 1995).

Observations of students involved in the *closed investigation* have shown that they mostly tend to focus on completing the task rather than learning from it. As a consequence, laboratory work tends to be rather "*hands on*" rather than "*minds on*" and students' use of the process is limited to that required to complete the activity (Berry *et al.*, 1999).

Typical behaviour during *closed investigation* can be summarised as following:

(i) *students focus on the procedure, which they follow as they would a recipe for baking a cake;*

(ii) *students' main goal is to complete the investigation;*

(iii) *the second goal is to achieve the "right" answer;*

(iv) *many students are able to complete the task with minimal mental engagement by following the given procedure.*

A description of the laboratory process given by one first course Physics student from the experimental group is an excellent demonstration of this: " *I start thinking about the experiment only when I write the report. In the laboratory I am too busy collecting the data"* (see Appendix R, Interview report). There is evidence from the literature that most students show little signs of learning from laboratory practices based on closed investigations (Tasker, 1981). Lack of freedom for creativity and genuine investigation in closed laboratory practice may result not only in a lack of developing the cognitive abilities such as creative thinking, problem-solving, scientific thinking and intellectual development, but also in developing rather negative attitudes towards laboratory practice. Berry et al. (1999) have reported that laboratories based on closed-investigations may generate an attitudes that laboratories involve little thinking.

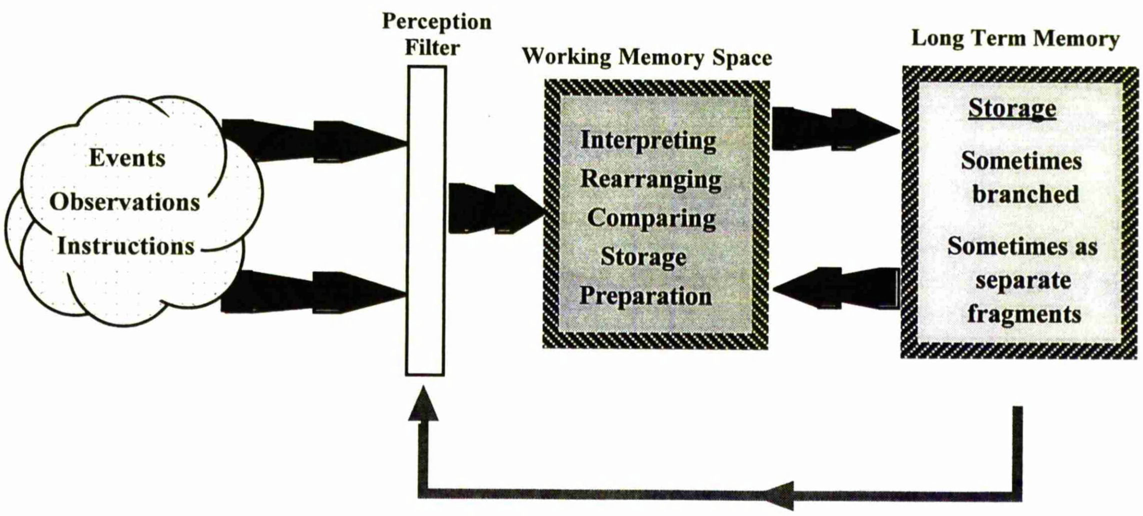
Previous work has shown the power of pre-lab exercises (to prepare the mind of a learner) and post-lab exercises (to apply what is learned on practice) in improving cognitive outcomes from university laboratory practice (Johnsone *et al*, 1994, Johnstone *et al.*, 1998). Unfortunately there was no opportunity to try out the pre- and post-labs designed by the researcher in practice with students. However, an opportunity was given to seek the views of a few students about their potential through semi-structured interviews. Students were given an example of pre- and post-labs designed for the experiment called "Spectrometer" (see Appendix T). The interviewed students were very positive about this specific pre- and post-lab as well as about the whole idea of pre-lab exercises. Students' evaluations of the post-lab were even more positive than of the pre-lab. Students found the idea of post-lab (which aim was to allow students to apply what they learned from experiment to solve some real-life problems) very encouraging and useful. The words of one student about post-lab summarise the opinions of all interviewed students: "*really-really good idea. It make sense of experiment, useful to set up the theory. I do not think anybody in the course will object*" (Full report of the interview can be found in the Appendix R). These views of students make it reasonable to assume that pre- and post-lab exercises, together with their cognitive value, have an attitudinal value as well. If the learning experience is meaningful and satisfying it will likely generate positive feelings and attitudes towards whole Physics course and the subject itself.

The Information Processing Model developed by Johnstone (1993) was used as a theoretical guide for designing pre- and post-lab exercises.

11.2 Information Processing Model

There are several versions of information-processing models (Sanford, 1985; Child, 1993, Johnstone, 1993). The model proposed by Johnstone (1993) has received wide recognition as a working tool providing explanations of mechanisms of learning. This Model (diagram 11-1) provides an explanation how the human brain handles input information and what kind of processes lead to meaningful learning.

Diagram 11-1: Information Processing Model



The Information Processing Model considers human memory as consisting of three main parts. They are sensory memory (perception filter), working memory and long-term memory. These three types of memory are interconnected to allow the information to flow from one to another (see diagram 11-1).

Perception filter plays a role of a filtration system, which allows us to be selective in sensory information to which we attend. Perception filter is activated by what is already stored in the long-term memory (this process is shown on the Diagram 11-1 by the feedback loop from long-term memory to perception filter).

Working memory is a part of the brain space where stimuli and information coming through the perception filter is held and manipulated before being passed for storage in the long-term memory or being rejected. This is a space of limited capacity. Johnstone (1984) has demonstrated that a sudden drop in the learner's performance takes place when a task load exceeds the upper limit of the learner's working memory capacity. It is supposed that probably only 6±2 bits of information can be held in the working memory while some operation with it is going on.

Long-term memory is a part of a human brain where processed information is stored and made available for recall. There appears to be no limit to the capacity of long-term memory (Solso, 1995). What is stored in the long-term memory and how it is stored affect the way the perception filter operates and, in education, defines what kind of learning process an individual operates. Ausubel et al (1978) describes two extremes in the learning process. At one end is a rote learning, where students attempt to learn by placing information in memory by repetition and in isolation from any other learned material. The other extreme is meaningful learning, in which new information is attached to existing learning, making it richer, more interconnected and accessible through many cross-linkages.

New information will be more easily learned if it is explained and also related to relevant ideas in the students' cognitive structure. Meaningful learning occurs when new information is linked to prior information in the learner's own cognitive structure. Johnstone (1997a), described meaningful learning as "*good, well-organised, branched, retrievable and usable learning*" while rote learning is "*at best, isolated, boxed learning that relates to nothing else in the mind of learner*".

"*If we want our students to have meaningful learning, our teaching has to create the atmosphere and opportunities for such learning to take place*" (Johnstone, 1997a). If what is already in the student's long-term memory is so crucial to the processing of new information, the preparation of long-term memory before learning is absolutely essential to enhance learning and to minimise misunderstanding.

On the basis of the Information Processing Model pre- and post-labs can be justified through the following cognitive and attitudinal outcomes:

- The *pre-lab* exercise prepares the mind for what is going to happen in the laboratory and, by reducing the working memory load may enable the student to engage mentally with the experiment and to think more critically;

- The *post-lab* exercise may offer opportunity to link the learning in the laboratory to previous knowledge which will provide the meaningful learning where obtained new knowledge will make sense and will be integrated in the previously existed cognitive system enriching the previous one. This will lead to better storage and hence to easier retrieval of information.

In both cases, the lab experience will involve more meaningful learning and may be useful in allowing students to develop more positive attitudes towards the learning of Physics in general.

11.3 Pre- and Post- labs, practical models

11.3.1. Pre-laboratory practice and the ways it can be conducted

In general, the aim of the pre-lab is to provide a student with information about the experiment before the laboratory through the following:

- providing a student with clear messages about aims and purposes of an experiment;
- providing or consolidating background theory underlying the experiment;
- providing or consolidating understanding of terminology used in the experiment;
- introducing students to apparatus used in the experiment as well as to safety procedures;
- preparing students to use the background theory to solve different kinds of problems they may meet during the experiment and after it.

Some science educators consider the role of the pre-lab as a "warming up" the minds of students before they come to the lab, so they can be prepared to *"recognise the expected changes, to be surprised when something different occurs, to have the requisite theory 'at the top of the head' to guide what is going to be experienced*" (Johnstone, 1997b). Before coming to the laboratory students should be convinced that the experiment is worth doing and that the results will be important and informative.

Different approaches towards a pre-lab design have been discussed:

a) reading the lab manual before starting experiment (Zaman, 1996);
b) solving different theoretical problems related to the experiment and answering certain questions about the experiment before being allowed in to the lab (Pickering, 1985);
c) doing computer simulations of experiment;
d) listening to a short talk about the most important points of the experiment in the first half hour of the lab session (Georgia Institute of Technology)
e) understanding audio-visual preparation (Kinzie *et al.,* 1993,).

The very common and widely used way of conducting pre-lab is to ask students to read a Manual before they come to the laboratory. In this case the Manual itself should provide students with clear identification of the aims (to make sense of what they are doing) and purposes of the experiment (why are they doing this experiment?), provide guidance on the background theory of the experiment and/or references to the relevant literature, explanations of terminology. Some pre-labs, in addition to the above material, may suggest that students answer some questions and/or to solve some problems related to the experiment. There are several examples of such pre-labs, which are known to have been successfully used in university laboratory practice in Chemistry (University of Glasgow, UK; Heriot-Watt University, UK; Universite de Paris-Sud (Orsay), France).

Doing computer simulations of the experiment and understanding of audio-visual presentations were found to be a more effective way of conducting pre-laboratory than listening to short talk of a demonstrator about the experiment (Georgia Institute of Technology, School of Chemistry and Biochemistry).

Because of the financial problems experienced by some universities, the reading of the Manual became the mostly widely used way of conducting pre-laboratory preparations. Pre-labs designed in this study were supposed to be an additional part for the existing level 1 Physics Laboratory Manual and students had to read the pre-lab and perform all the exercises before they came to the laboratory.

11.3.1.1 Pre-lab design in this study

While designing the pre-lab exercises the following aims were as follows:

1) to provide a student with a clear idea about the aim of the laboratory work (**What will I be doing in this laboratory?**);

2) to provide a student with a clear message about the purpose of the laboratory (**Why am I doing this lab? What will this laboratory work teach me about**?);

3) to provide a student with messages about possible outcomes of the laboratory practice (**What new skills can I expect to obtain from this lab**?);

4) to help a student to see the links between the laboratory practice and his/her course of study (**To which part of my Physics course does this lab belong**?)

5) to provide a student with information about the background theory necessary to perform experiment successfully (**What should I know before I begin the lab?).**

The whole idea of such a pre-lab is to convince students that the experiment is worth doing, that the results will be important and informative and that they will learn much from the laboratory if they have done proper preparation for it. Examples of the pre-labs designed for the first term Physics laboratory practice are in the Appendix T (experiments: Acceleration Motion, The Spectrometer and Optics).

To motivate students to do some preparation for the laboratory at home, their preparation would be checked using a short test. The mark obtained for pre-lab would contribute to the total mark for the laboratory practice. A multiple-response test was used to check students' preparations since it has an advantage over traditionally used multiple-choice test in eliminating the element of guessing. In a multiple-response test it is not necessary to have only one right answer from the number of choices as in the multiple-choice test: perhaps all options are right, perhaps no one option is right or there can be a different number of right options in different questions. Examples of the designed tests for three experiments in the first term level 1 Physic course are in the Appendix T.

11.3.2 Post-labs, practical design and working models

The purpose of the post-lab can be considered as re-exploration and extension of what students had learned from the pre-lab and in the laboratory while doing an experiment. This can be achieved through solving some relevant, preferably real life or every day problems, or through exploration and discussion of the outcomes of the experiment, or through discussing the links and cross-referencing between the experiment and different topics underlying it, modifications, other cases.

Problem solving is an excellent way to make sense of the theory students learned from experiment. Carefully designed problem-solving will help students to see the links between different topics and even subjects, to extend and enrich knowledge they have obtained to explain something real, as well as to build their confidence in using knowledge in practice.

Another good technique to build links and see connection is a concept map (Novak and Gowin, 1984) or mind map (Buzan, 1995). Asking students to build a mind map of the experiment can be considered as a part of the post-lab exercise. Putting the main concept of an experiment which they performed at the centre and drawing the links between it and different concepts, topics, problems and applications related to it should be a good exercise in providing a visual appreciation of how the concept is embedded in a student's cognitive structure. Instead of drawing a concept map students can be asked to arrange cards bearing the names of experiment and of topics in linked patterns, and to write on each link the nature of the relationship (White, 1996).

Working examples of the post-lab exercises can be found in the Laboratory Manuals of several universities in Chemistry (University of Glasgow, University of Heriot-Watt, Universite de Paris-Sud (Orsey), France).

Post-lab together with pre-lab exercises were applied to level 2 University of Glasgow Physics students in the way of problem-solving exercises (Zaman, 1996). It was demonstrated that students who began the laboratory with pre-lab exercises significantly outperformed in the post-lab problem solving those who began laboratory without pre-lab. This work has demonstrated the importance of both parts, pre-lab and post-lab, in laboratory practice.

11.3.2.1 Post-lab design in this study

Post-lab exercises designed in this study were in form of the problem-solving exercises which students should perform at the end of their laboratory practice and then discuss the results with their demonstrator. The aim of the post-lab was to help students to extend the knowledge they obtained during laboratory practice by solving different real-life problems based on the concepts learned from pre-lab and in the laboratory. Examples of the designed post-labs are in the Appendix T.

11. 4 Conclusion

It is not valid to draw conclusions about usefulness and importance of pre- and post-labs designed in this study on the basis of the responses of only eleven interviewed students. However, all eleven students were extremely positive in their responses about the idea of pre- and post-labs, the way they were designed for the particular experiments and their usefulness in laboratory practice. From the previous research work (Johnstone *et al*, 1994; Zaman, 1996) the cognitive value of pre- and post-labs was established, but nothing was said about their attitudinal value. Views of interviewed students clearly showed that meaningful and interesting laboratory work will be likely evaluated positively by students and will be likely to generate positive attitudes towards laboratory work in general. Evidence exists that this may improve the attitudes towards a university Physics course itself.

However, there is no clear evidence that improving attitudes towards laboratory practice would stop students from leaving Physics, although it is highly unlikely that the reverse would happen. Further and more detailed work needs to be done in this area.

Chapter 12

Summary and Conclusions

The main results obtained in this research can be summarised using the diagram 12-1, where stages at which the data were collected and analysed are shown. Stages marked as ◍ on the diagram 12-1 show the choice nodes when students should normally take a decision about their further studies: about Standard Grade courses at the end of S2, about Higher Grade courses at the end of S4, about further studies in Higher Education (HE) at S5/S6 stages and about their degree subjects at the end of university level 1 (L1) and level 2 (L2) courses.

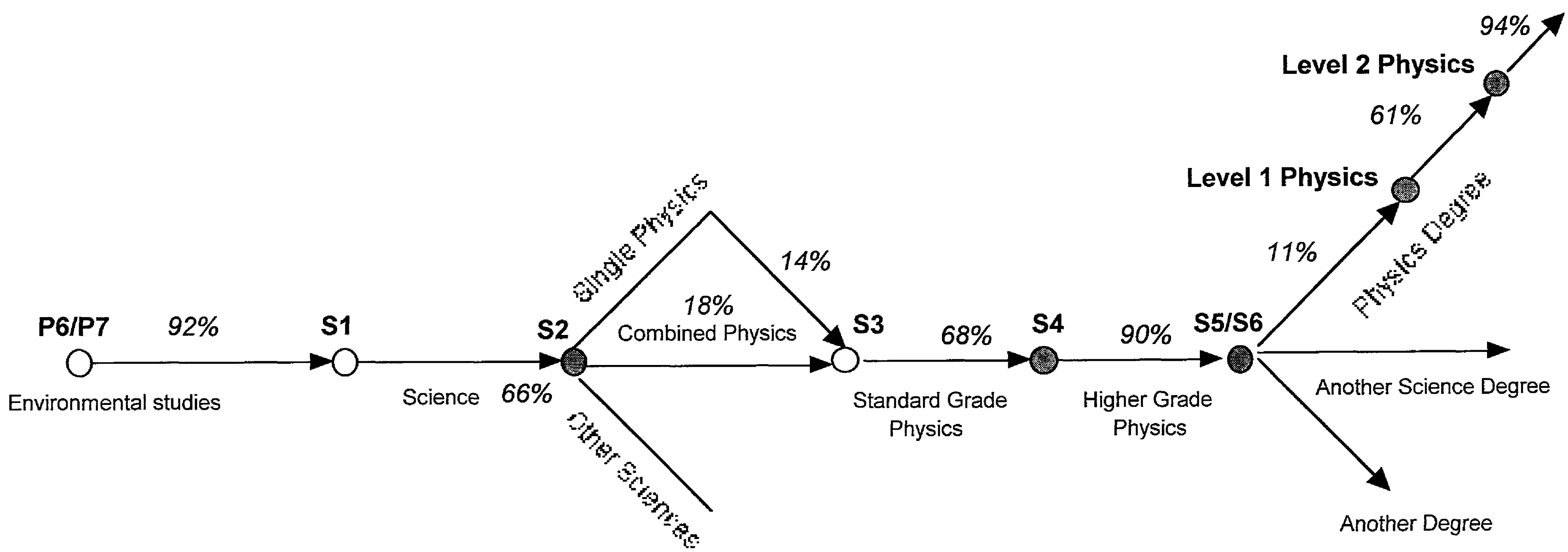
Different factors have emerged at different stages, which influenced students' decisions either to study Physics further or reject it. These factors appeared to be very different: some of them are related to school, in particular to Physics lessons (in-school factors), others are quite external to school and related to the perceived status and rewards that knowledge of Physics or Physics-based careers can offer. The priority given to different factors also differ for students from different age groups. The picture obtained was the following:

Primary P6/P7 (age 10-11): Pupils' attitudes towards science lessons were very positive. No difference was observed between boys' and girls' attitudes. However, areas of interests of boys and girls in Physics were clearly distinct. Around 85% of P6/P7 pupils expressed a desire to study more science in secondary school. The main factors which motivated them to study more science were:

	%
Interest to know more about science	49
Enjoyment of science lessons	46

The first factor can be attributed to the intrinsic curiosity of pupils, which can be generated by several factors: natural curiosity of children of this age, experiences at

Diagram 12-1: The way towards a degree in Physics (stages involved in the present research)



Note: 1. ● marks choice nodes when pupils should normally decide about their further studies

2. percentages on the diagram reflect pupils' positive intentions towards further studies of science/physics

home and school. Primary pupils indicated that their interest in science was generated mostly by their parents, with the teacher and lessons being given a less significant role.

Secondary S2 *(age 13 - a decision making stage)*: Attitudes of S2 pupils towards science lessons were significantly less positive than attitudes of primary P6/P7 pupils. An obvious "erosion" of girls' attitudes towards science was observed at this stage relative to the primary school stage. Nonetheless, 34% of S2 pupils expressed a desire to study Physics for Standard Grade (14% just Physics and 20 % Physics combined with one or more other Sciences). The ratio of boys to girls planning a Standard Grade Physics was 2:1. Areas of interest for boys and girls in Physics were distinct. It was observed that boys' interest towards science at this stage was significantly higher than girls' interests. Main factors that influenced pupils' choice of Physics towards Standard Grade were:

	%
usefulness for a further career	44
interest in the subject	29

At this stage pupils have an integrated science course with elements of Chemistry, Biology and Physics which is usually delivered to pupils by one teacher. It should be recognised that at this stage pupils do not have a clear understanding of what Physics is really about. The main element which attracts S2 pupils to Physics is the perceived career benefits arising from the subject.

Secondary S3 *(age 14)*: This stage is not a decision making one. However, it was observed that 68% of pupils doing S3 Standard Grade Physics were thinking about Higher Grade Physics. The main reasons for this were:

	%
usefulness for a career	51
good basis for other subjects	36
interest in the subject	36
better chance to enter university	12

Pupils' attitudes towards and their views of themselves in Standard Grade Physics were very positive. No differences between boys' and girls' attitudes were observed. However, areas of interest of boys and girls in Physics topics were different.

Secondary S4 *(age 15 - a decision making stage)*: Students must decide whether or not to take Physics for a Higher Grade. Attitudes of pupils towards Higher Grade Physics were extremely positive. Significant improvements in students' attitudes and perceptions of self from S3 to S4 Standard Grade Physics course were observed. 90% of S4 pupils expressed intentions to take Physics for Higher Grade explaining this by:

	%
enjoyment of the subject	69
good grades in the subject	56
interest in the subject	44
usefulness for a career	31

This can be considered as a direct manifestation of the success of the Standard Grade Physics. No differences between girls' and boys' attitudes and intentions were observed. Areas of interests of girls and boys in Physics remained different.

Secondary S5/S6 *(age 16/17 - a decision making stage)*: At this stage pupils have to decide about their further study at university. Attitudes of S5/S6 pupils towards their Higher Grade Physics course were significantly lower than attitudes of younger pupils towards Standard Grade Physics. That was true for girls and boys. It seems that, after Standard Grade Physics with its applications-led syllabus, the Higher Grade Physics course was a big disappointment for some students, especially for boys. About 11% of Higher Grade Physics pupils expressed a desire to study Physics at university. No statistical response can be obtained about the reasons for such a desire from such a small sample. Analysis of factors which brought level 1 and level 2 Physics course students to study Physics at the University of Glasgow after S5/S6 revealed four main factors:

	%
enjoyment of subject at school	87
good grades at school	74
likely career opportunity	49
teacher at school	27

These factors were similar for boys and girls.

Level 1 university Physics course *(age 17/18 - a decision making stage)*: Data from the analyses of 98/99 level 1 Physics students revealed that 61% of the level 1 students involved in this research were planning a degree in Physics. The main reasons for this intention were:

	%
interest in the subject	50
likely career opportunity	18
enjoyment of the subject	13

Attitudes of the level 1 Physics students towards their Physics course were rather neutral. Data have shown (over a three-year period) that around 20% of students planning a degree in Physics change their minds and leave the Physics Department after the level 1 course. The reasons for many students leaving Physics were mainly their low level of enjoyment of poor views of themselves in the university Physics course. These feelings might have been generated because of the difficulties some students experienced in the course due to their lower level of ability in Physics and Mathematics and lower level of self-confidence compared to those of students remaining in Physics. It was observed that only mostly able (Grades in Physics and Mathematics higher than C) and self-sufficient students remain in the subject. However, the course of the level 1 lectures (which was described by students as rather "dry") and the laboratory practice (which was not well rated) perhaps had some negative influence as well.

Level 2 university Physics course *(age 18/19 - a decision making stage)*: Level 2 students' attitudes towards university Physics course were significantly more positive than attitudes of the level 1 students. 94% of the level 2 students were planning a degree in Physics mainly because:

	%
interest in the subject	41
likely career opportunities	31
good grades in the subject	13

Attitudes of females and males students were similar.

12.1 Discussion

Following the results obtained it can be seen that at the early stages (P6/P7, S2, S3) students were mostly encouraged towards Science/Physics by "out-class" factors such as "career opportunities" and "good basis for other subjects". However, as was clearly observed, when satisfaction from Physics class-room experience was growing "in-class" factors became more significant in students' choice of Physics for Higher Grade (S4) and for a degree (level 1 and level 2 university Physics courses).

The situation in Physics in Scotland was described as different from the rest of the UK and even Europe. Problems experienced by some countries (decline in the number of Physics undergraduates (Germany, USA, [Leath, 1998]), crisis in Physics teaching recruitment (England, Sweden), fall in number of A-level Physics entries (Durrani, 1998)) are not relevant to Scotland (Ireson, 1998). Two factors have emerged in the present study which influence pupils' choice of Physics for further studies:

(1) Positive experience in Physics in school/university

(2) Career prospects arising from Physics.

Looking at the value which students gave to these factors in taking a decision about further studies of Physics, the following picture was obtained:

Table 12-1: Students' evaluations of factors, which <u>influenced their choice of Physics for further studies</u>:

Age	**10-11**	**13**	**14**	**15**	**16/17**	**17-18**	**18-19**
Stage	**P6/P7**	**S2**	**S3**	**S4**	**S5/S6**	**L1**	**L2**
School/university experience	High	Low	Mod.	High	High	High	High
Career prospects	Low	High	High	Mod.	High	Low	Mod.

The data in the table 12-1 show that, at every stage, pupils' intentions towards studying Physics were determined mainly by their attitudes towards the subject. At some stages positive attitudes towards Physics were generated mostly by positive beliefs about the subject (cognitive way of attitude formation) rather than positive experience in the subject at school (affective way of attitude formation) [S2 stage], at some stages the situation was opposite and the positive experience in Physics was more important than beliefs about it [L1 and L2]. However, there is a stage at which both factors were positive: positive experience in Physics at school and positive beliefs about the subject [S5/S6]. Those pupils who had both these two factors positive came to study Physics at university.

It is possible that these results point to potential explanations for the "unusual" situation in Physics in Scotland. Not only does the Standard Grade Physics course attract a very high proportion of pupils of both genders to Higher Grade Physics, but also there are general trends in society which considers Physics as a useful, important, relevant subject which may open many doors to future careers. Analysis of the literature revealed that in England Physics is perceived as rather odd, only for "very brainy, and those who were born that way" (Woolnough, 1994; Osborne, Driver and Simon, 1998).

The general picture, which was obtained from the analyses of pupils' and students' attitudes towards their current Science and Physics course, was the following (where the terms "High", "Moderate" and "Low" have been used to categorise the data obtained):

Table 12-2: Picture of students' attitudes towards their current Science/Physics course

	P6/P7	**S2**	**S3**	**S4**	**S5/S6**	**L1**	**L2**
School/university experience in Science/Physics	High 69%	High 53%	High 48%	High 55%	Mod. 39%	Low 28%	High 52%

Looking at the data in these two Tables (12-1 and 12-2) it can be seen that:

- Although attitudes of S2 pupils towards their science lessons were positive (although significantly lower than attitudes of primary P6/P7 pupils) nevertheless, the role of class-room experience in Physics was low in forming pupils' positive attitudes towards Physics and in pupils' choice of Physics for a Standard Grade. S2 students' choice of Physics for Standard Grade was determined mostly by students' perceptions of Physics as a useful subject for their further career. A balanced syllabus in Physics reflecting interests of both genders is of particular importance at this stage to attract more pupils to the subject and to solve the "problem of girls in Physics".

- The Standard Grade Physics course (S3 and S4) was evaluated highly by pupils and it was observed that significant majority of pupils doing Physics at these stages move to Higher Grade Physics (S5).

- The Higher Grade Physics course (S5/S6) revealed syllabus problems. Comparing data in the Tables 12-1 and 12-2 it can be suggested that if the experience at S5/S6 level in Physics were more positive, more students might come to university to study the subject rather than see Higher Physics as a service course for entry into other careers.

- Level 1 Physics experience at the University of Glasgow was regarded poorly in terms of attractiveness of the subject. Probably, if students' experience in the level 1 Physics course were more stimulating, more students would choose to continue with the subject to degree level.

12.2 Conclusions

(a) The early primary school experience reflects natural curiosity and the desire to explore and experiment. This natural interest is not blunted by primary science lessons. However, in S1 and S2 interest declines. The syllabus seems to be less satisfactory and interest in and commitment to science fall. This fall was especially marked for girls. This may arise partly because, by this stage, pupils need enthusiastic commitment and this is not apparent, perhaps, reflecting the difficulties teachers have in being asked to move outside their own areas of enthusiasm and commitment. Despite this, significant numbers of pupils still opt for Physics at Standard Grade (mainly because of the perceived value of Physics for a career) and their enthusiasm steadily rises during the two-year Standard grade Physics course.

(b) Why do pupils still choose Physics at Standard Grade despite their poor experience in it in S1 and S2? This is almost certainly a social effect. Pupils and their parents are aware of the value of Physics for career in general. Physics is seen as a normal, but a useful subject. It is acceptable for pupils to select Physics, even for girls. However, stereotypes of Physics as a "masculine field of activity" have a place (probably not as strong as in England) since twice as many boys as girls choose to study Physics.

(c) The Physics course at Standard Grade is very successful in terms of promoting pupils' interests towards the subject. It looks like the structure of the course, which emphasises the application-based approach rather than a content-based approach is very appealing to pupils.

(d) Despite the fall in perceptions of Physics at S5/S6 due to a course which is very difficult and a syllabus which is less appealing, pupils consider taking Physics at university. However, there is a subtle but significant change. For the majority of students, Physics is no longer being taken for its own sake but there is a tendency to see Physics as a service subject, giving access to other options. This pattern continues in the Level 1 university Physics course. Physics is still seen as hard, and the work is too unrelated to real life. Traditional Physics course is not drawing committed students to Physics and, when the going becomes tough, they opt into other subjects, despite having been able to cope at earlier stages. The key factors influencing this are: lack of intrinsic interest and perceived relevance, lack of perceived clear career prospects. Thus, only the most committed stay in Physics.

In general: what are the factors that make the situation in Physics in Scotland unusual? Three factors can be suggested:

(1) The structure of Scottish secondary and Higher Education: the broad structure at Higher Grade (where students may choose up to five subjects for a Higher Grade) and the flexible structure at University (where students take at least three subjects in their first year of study and only then choose their Honours subject(s)). So, many students do level 1 Physics only as a service subject.

(2) A highly successful application-led syllabus at Standard Grade appealing to both genders and attracting pupils into Higher when the value of Physics for access to several courses is apparent.

(3) The public perception of Physics: in Scotland Physics is perceived as a useful, relevant, important subject to study. Data have shown that for the last forty years Physics has been fifth most popular subject taken for Higher Grade and

after the introduction of the Standard Grade Physics it has moved up to fourth place, exceeding Chemistry in popularity. These perceptions of Physics are rather cultural perhaps particular to Scotland and this phenomenon would be interesting to explore in details.

12.3 Main problem areas that need to be addressed

In the light of the results obtained, the following areas need to be addressed:

(a) Syllabus overhaul to bring in themes that attracts both sexes.
(b) S1/S2 stage: syllabus and organisation need major overhaul.
(c) Higher Grade Physics course should be less difficult and abstract, but more modern and applications-led.
(d) Level 1 university Physics course needs to be modernised and much more appealing to students' interests and aspirations. This is particularly important for the first term of the Physics course.
(e) Laboratory practice and experience in level 1 Physics university course might be improved using pre and post labs.
(f) Better advertisement of openings from Physics.

12.4. Further studies

(a) Effect of the pre and post laboratory exercises on attitudes towards laboratory practice and on students' attitudes towards university Physics course in general;

(b) Persistence of students in Physics: the role of self-confidence. Is this quality essential to survive in other science subjects (Chemistry and Biology)?

(c) Gender issues: further studies on details of themes that attract or repel.

(d) The role of a teacher in attitudes towards Physics at school? What kind of teacher's quality makes him/her to be associated so strongly with university students' positive experience in Physics at school? Are there any differences between genders?

(e) Detailed exploration of factors that cause an observed decline in attitudes of S1/S2 pupils towards science.

(f) The social effect: what is it that allows Physics to be seen as acceptable, normal, desirable, important, and not impossible in Scotland and why is the subject perceived as rather "elite" in England?

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Appendix A

Examples of Questionnaires

Primary P6/P7

University of Glasgow

Centre for Science Education

Please complete as much of the questionnaire as you can. Most questions can be answered simply by putting a tick in the relevant box(es) or by writing in your answer.

1. Are you: ☐ Girl ☐ Boy

2. What primary school do you attend at the moment? ....

3. Which of the following topics interest you?
Tick as many as you like.

- ☐ how musical instruments work
- ☐ why we usually have a rainbow after the rain
- ☐ is it safe to use nuclear power for producing electricity
- ☐ why the weather is changing all the time
- ☐ why use of X-rays can be harmful for the human body
- ☐ why do we have earthquakes
- ☐ how to construct a simple hair dryer
- ☐ how to solve the world food problem
- ☐ how does a TV remote control work
- ☐ why do we have summer, autumn, winter and spring
- ☐ how the power station works

*All the topics from the question 3 can be explained and discussed in **science** lessons. So, the part of your environmental studies lessons where you study the problems like those above we will further call **science** lessons.*

This is an example. If you had to describe "a racing car" you could do it like this:

quick	☑	☐	☐	☐	☐	☐	*slow*
important	☐	☐	☑	☐	☐	☐	*unimportant*
safe	☐	☐	☐	☐	☑	☐	*dangerous*

The positions of the ticks between the word pairs show that you consider it as very quick, slightly more important than unimportant, and quite dangerous.

Use the same method of ticking to answer the questions 4,5.

4. What are your opinions about your **science lessons**?

I like science lessons	☐	☐	☐	☐	☐	☐	I hate science lessons
boring lessons	☐	☐	☐	☐	☐	☐	interesting lessons
I enjoy the lessons	☐	☐	☐	☐	☐	☐	I do not enjoy the lessons
easy lessons	☐	☐	☐	☐	☐	☐	complicated lessons

5. How do you feel yourself about your **science** course at school?

I feel I am coping well	☐	☐	☐	☐	☐	☐	I feel I am NOT coping well
I learn a lot of new	☐	☐	☐	☐	☐	☐	I learn nothing new in science lessons
I am NOT obtaining new skills	☐	☐	☐	☐	☐	☐	I am obtaining a lot of new skills
I hate doing experiments	☐	☐	☐	☐	☐	☐	I am enjoying doing experiments
I like the teacher	☐	☐	☐	☐	☐	☐	I dislike the teacher
science is important subject	☐	☐	☐	☐	☐	☐	science is unimportant subject

Please turn the page over

6. Would you like to study more science in secondary school?

Yes, because..

No, because..

We would like to know what do you think about scientists - people who work in science or teach science.

9. As a general rule, is each statement below **true** or **false**?

True	False	
☐	☐	all scientists are very intelligent people
☐	☐	being a scientist is very interesting
☐	☐	scientists usually wearing spectacles
☐	☐	scientists work to make discoveries
☐	☐	being a scientist is hard
☐	☐	scientists usually are rich people
☐	☐	female don't like being scientists
☐	☐	being a scientist is dangerous for the health
☐	☐	scientists should wear goggles while working
☐	☐	being a scientist is not popular our days

7. Which of these do you think is going to be the most interesting to do in secondary school?

- ☐ playing in a school sports team
- ☐ painting pictures
- ☐ cooking or metalwork
- ☐ doing science experiments
- ☐ playing musical instruments
- ☐ learning foreign languages
- ☐ solving different kind of problems

10. What would you most like to be when you leave secondary school?

- ☐ a TV news reader
- ☐ an air-line pilot or stewardess
- ☐ a scientist
- ☐ a doctor
- ☐ a lawyer
- ☐ an architecter
- ☐ a busiriessmen/businesswomen
- ☐ a professional tennis player
- ☐ an engineer
- ☐ a teacher

11. Which school subject is the best for helping you to get a job when you leave school?

- ☐ English
- ☐ Geography
- ☐ Science
- ☐ Music
- ☐ History
- ☐ Mathematics
- ☐ Craft, design, technology
- ☐ Home education

12. I became interested in science thanks to:
Tick as many as you like.

- ☐ scientific TV programs
- ☐ my parents
- ☐ science lessons
- ☐ literature
- ☐ exhibitions, demonstrations, festivals
- ☐ my teacher
- ☐ my friends
- ☐ else, *please indicate*..

13. What are you looking forward to learn about in your science lessons?..

....

....

Thank you very much for answering these questions and all the best to you in your study!

Secondary S2

University of Glasgow

Centre for Science Education

This questionnaire is a part of a project investigating reasons for studying science subjects. All information obtained will be treated in complete confidence.

Please complete as much of the questionnaire as you can. Most questions can be answered simply by putting a tick in the relevant box(es) or by writing in your answer.

1. Are you: ☐ Girl ☐ Boy

2. What secondary school do you attend at the moment? ....

3. ***Example:*** I think Geography is the most interesting subject.
Fill in the **school subject** that you think best fits each description below:

School subject		*School subject*	
a).....................	is most interesting	b)......................	is most important .
c).....................	is most enjoyable	d)......................	is most boring
i).....................	is mostly suitable for girls	f)......................	is mostly suitable for boys
j).....................	is useless for girls	h)......................	is useless for boys

4. Would you like to study more **Physics** next year?

☐ Yes, because ....
☐ No, because ....

5. As a general rule, is each statement below **true** or **false**?

True	*False*	
☐	☐	all Physicists are very intelligent people
☐	☐	being a Physicist means finding a job is easy
☐	☐	Physicists are involved in the process of describing nature and its laws
☐	☐	Physicists have a very high salary
☐	☐	Physicists work to make our lives safer and more comfortable
☐	☐	Physicists are strongly involved in the study of the human body
☐	☐	Physicists are very enthusiastic people and often work for the sake of personal interest
☐	☐	Physicists have excellent career opportunities.

6. Would you like to be a **Physicist**?

☐ Yes ☐ No ☐ I don't know yet

7. Have you already thought about which career you would like to follow ?

☐ Yes ☐ No

If you answered **"Yes"** what is the career and why this interest you?

....

....

8. What do you enjoy most in your **science lessons**?
Tick as many as you like.

☐ studying the theory
☐ doing practical work
☐ explaining events of daily life
☐ studying science applications in life
☐ studying how science can make our lives healthier
☐ studying about the human body
☐ studying how science can help me in life
☐ studying making equipment
☐ studying how science can improve my life
☐ solving every day problems
☐ something else, please indicate..

Please, turn the page over.

9. Which of the following topics interest you?
Tick as many as you like.

- ☐ how musical instruments work
- ☐ why we usually have a rainbow after the rain
- ☐ is it safe to use nuclear power for producing electricity
- ☐ how can we increase the power of the car engine
- ☐ how does the telescope work
- ☐ which atmospheric factors influence the weather on the planet
- ☐ why use of X-rays can be harmful for the human body
- ☐ why do we have earthquakes
- ☐ how to construct a simple device to measure the level of radiation
- ☐ how to solve the world food problem
- ☐ how can I earn money by applying my knowledge
- ☐ how to understand the way electrical equipment works

This is an example. If you had to describe "a racing car" you could do it like this:

quick	☑	☐	☐	☐	☐	☐	*slow*
important	☐	☐	☑	☐	☐	☐	*unimportant*
safe	☐	☐	☐	☐	☑	☐	*dangerous*

The positions of the ticks between the word pairs show that you consider it as very quick, slightly more important than unimportant, and quite dangerous.

Use the same method of ticking to answer the questions 10, 11.

10. What are your opinions about your **science lessons** ?

I like science lessons	☐	☐	☐	☐	☐	☐	I hate science lessons
boring lessons	☐	☐	☐	☐	☐	☐	interesting lessons
easy lessons	☐	☐	☐	☐	☐	☐	complicated lessons
I'd like to spend less time on it	☐	☐	☐	☐	☐	☐	I'd like to spend more time on science
enjoying lessons	☐	☐	☐	☐	☐	☐	boring lessons
useless lessons	☐	☐	☐	☐	☐	☐	important lessons

11. How do you feel yourself about your **science** course at school?

I feel I am coping well	☐	☐	☐	☐	☐	☐	I feel I am not coping well
I am enjoying subject	☐	☐	☐	☐	☐	☐	I am NOT enjoying subject
I find it very very hard	☐	☐	☐	☐	☐	☐	I find it very easy
I am obtaining a lot of new skills	☐	☐	☐	☐	☐	☐	I am NOT obtaining new skills
I hate practical work	☐	☐	☐	☐	☐	☐	I am enjoying practical work
I like the teacher	☐	☐	☐	☐	☐	☐	I dislike the teacher
It is definitely "my" subject	☐	☐	☐	☐	☐	☐	It is definitely NOT "my" subject

12. Would you like to do **Physics** for Standard Grade ?

☐ YES, because...

....

☐ NO, because...

....

13. Which **science** subject(s) are you planning to take for **Standard Grade**?

....

....

....

Thank you very much for answering these questions and all the best to you in your study!

Secondary S3

University of Glasgow
Centre for Science Education

This questionnaire is a part of a project investigating reasons for studying science subjects.
All information obtained will be treated in complete confidence.

Please complete as much of the questionnaire as you can. Most questions can be answered simply by putting a tick in the relevant box(es) or by writing in your answer.

1. Are you: ☐ Girl ☐ Boy

2. What secondary school do you attend at the moment ? ....

This is an example. If you had to describe "a racing car" you could do it like this:

quick	☐☐☐☐☐☐	*slow*
important	☐☐☐☐☐☐	*unimportant*
safe	☐☐☐☐☐☐	*dangerous*

The positions of the ticks between the word pairs show that you consider it as very quick, slightly more important than unimportant, and quite dangerous.

Use the same method of ticking to answer the questions 3,4.

3. What are your opinions about your **school Physics** lessons?

I like Physics lessons	☐☐☐☐☐☐	I hate Physics lessons
boring lessons	☐☐☐☐☐☐	interesting lessons
easy lessons	☐☐☐☐☐☐	complicated lessons
useless lessons	☐☐☐☐☐☐	important lessons
enjoying lessons	☐☐☐☐☐☐	boring lessons

4. How do you feel yourself about your **school Physics** course?

I am enjoying subject	☐☐☐☐☐☐	I am NOT enjoying subject
I feel I am NOT coping well	☐☐☐☐☐☐	I feel I am coping well
I find it very easy	☐☐☐☐☐☐	I find it very hard
I am growing intellectually	☐☐☐☐☐☐	I am NOT growing intellectually
I am obtaining a lot of new skills	☐☐☐☐☐☐	I am NOT obtaining a lot of new skills
I hate practical work	☐☐☐☐☐☐	I am enjoying practical work
I am getting better in subject	☐☐☐☐☐☐	I am getting worse in subject
I dislike the teacher	☐☐☐☐☐☐	I like the teacher
it is definitely "my" subject	☐☐☐☐☐☐	It is definitely NOT "my" subject

5. What do you enjoy most in your **Physics lessons** ?
Tick as many as you like.

studying the theory ☐ studying about human body
doing practical work ☐ studying how Physics can help me in life
explaining natural phenomena ☐ studying making equipment
studying Physics applications in life ☐ studying how Physics can improve my life
studying how Physics can make our lives healthier ☐ solving every day problems

6. Do you know where people with a Degree in Physics can work?

☐ No, I don't ☐ Doesn't concern me ☐ Yes, I do (*can you give some examples*)........................
....

7. To be a Physicist is likely to be:
Tick as many as you like.

☐ interesting ☐ not popular ☐ not bad
☐ hard ☐ high status ☐ popular
☐ enjoyable ☐ stupid ☐ well paid

8. Would you say that **knowledge of Physics** makes your life more interesting?

☐ Yes ☐ No ☐ Never thought about it

Please, turn the page over

9. Which of the following topics interest you?
Tick as many as you like.

- ☐ how musical instruments work
- ☐ why we usually have a rainbow after the rain
- ☐ is it safe to use nuclear power for producing electricity
- ☐ how can we increase the power of the car engine
- ☐ how does the telescope work
- ☐ which atmospheric factors influence the weather on the planet
- ☐ why use of X-rays can be harmful for the human body
- ☐ why do we have earthquakes
- ☐ how to construct a simple device to measure the level of radiation
- ☐ how to solve the world food problem
- ☐ how can I earn money by applying my knowledge
- ☐ how to understand the way electrical equipment works

10. Would you like to do **Physics for Higher Grade** ?

☐ YES, because...

....

☐ NO, because...

....

11. Other than Physics are you studing Chemistry or Biology this year? *Please Tick*

☐ Chemistry ☐ Biology

12. Are you thinking of going to the **University** after school?

☐ Yes ☐ No ☐ Don't know yet

The questions 13-15 are only for those who answered "Yes" in Question 11.

13. Why are you going to **enter University** after school?
Tick as many as you like.

- ☐ want to continue study (*what subject, if known*) ....
- ☐ get away from home
- ☐ normal thing to do after finishing school
- ☐ I feel it is expected from me, (*by whom?*) ....
- ☐ interesting job in future
- ☐ social pressure and norms
- ☐ other factors (*please, indicate*)...

14. Do you know already which University would you prefer to enter?

☐ Yes (indicate, please)... .... ☐ No

15. If you answer "Yes", could you indicate why would you like to enter this particular University?
Tick as many as you like.

- ☐ It has a good academic reputation
- ☐ It is near my home
- ☐ It is the best one for subject(s) I want to study
- ☐ It is the only University which runs the course(s) I want to take
- ☐ The University seemed to offer excellent extra facilities
- ☐ My parents suggested to me to enter this University
- ☐ I was encouraged by demonstrations from this University
- ☐ I have some friends from this University
- ☐ any other reason, please indicate ....

Thank you very much for answering this questionnaire and all the best in your study!

Secondary S4 (1997/98)

University of Glasgow
Centre for Science Education

This questionnaire is a part of a project investigating reasons for studying science subjects. All information obtained will be treated in complete confidence.

Please complete as much of the questionnaire as you can. Most questions can be answered simply by putting a tick in the relevant box(es) or by writing in your answer.

1. Are you: ☐ Girl ☐ Boy

2. What secondary school do you attend at the moment ? ....

This is an example. If you had to describe "a racing car" you could do it like this:

quick	☑ ☐ ☐ ☐ ☐ ☐	*slow*
important	☐ ☐ ☑ ☐ ☐ ☐	*unimportant*
safe	☐ ☐ ☐ ☐ ☑ ☐	*dangerous*

The positions of the ticks between the word pairs show that you consider it as very quick, slightly more important than unimportant, and quite dangerous.

Use the same method of ticking to answer the questions 3,4.

3. What are your opinions about your **school lessons** lessons?

I like Physics lessons	☐ ☐ ☐ ☐ ☐ ☐	I hate Physics lessons
boring lessons	☐ ☐ ☐ ☐ ☐ ☐	interesting lessons
easy lessons	☐ ☐ ☐ ☐ ☐ ☐	complicated lessons
useless lessons	☐ ☐ ☐ ☐ ☐ ☐	important lessons
enjoying lessons	☐ ☐ ☐ ☐ ☐ ☐	boring lessons

4. How do you feel yourself about your **school Physics** course?

I am enjoying subject	☐ ☐ ☐ ☐ ☐ ☐	I am NOT enjoying subject
I feel I am NOT coping well	☐ ☐ ☐ ☐ ☐ ☐	I feel I am coping well
I find it very easy	☐ ☐ ☐ ☐ ☐ ☐	I find it very hard
I am growing intellectually	☐ ☐ ☐ ☐ ☐ ☐	I am NOT growing intellectually
I am obtaining a lot of new skills	☐ ☐ ☐ ☐ ☐ ☐	I am NOT obtaining a lot of new skills
I hate practical work	☐ ☐ ☐ ☐ ☐ ☐	I am enjoying practical work
I am getting better in subject	☐ ☐ ☐ ☐ ☐ ☐	I am getting worse in subject
I dislike the teacher	☐ ☐ ☐ ☐ ☐ ☐	I like the teacher
It is definitely "my" subject	☐ ☐ ☐ ☐ ☐ ☐	It is definitely NOT "my" subject

5. What do you enjoy most in your **Physics lessons** ?
Tick as many as you like.

- ☐ studying the theory
- ☐ doing practical work
- ☐ explaining natural phenomena
- ☐ studying Physics applications in life
- ☐ studying how Physics can make our lives healthier
- ☐ studying about human body
- ☐ studying how Physics can help me in life
- ☐ studying making equipment
- ☐ studying how Physics can improve my life
- ☐ solving every day problems

6. Do you know where people with a Degree in Physics can work?

☐ No, I don't ☐ Doesn't concern me ☐ Yes, I do (*can you give some examples)*........................
....

7. To be a Physicist is likely to be:
Tick as many as you like.

- ☐ interesting
- ☐ hard
- ☐ enjoyable
- ☐ not popular
- ☐ high status
- ☐ stupid
- ☐ not bad
- ☐ popular
- ☐ well paid

8. Would you say that **knowledge of Physics** makes your life more interesting?

☐ Yes ☐ No ☐ Never thought about it

Please, turn the page over

9. Which subjects do you plan to take at **Higher Grade**?

Subject 1 .... **Subject 4** ....
Subject 2 .... **Subject 5** ....
Subject 3 .... **Subject 6** ....

10. Which factor(s) influence your choice of subject(s) above at **Higher Grade**?
Tick as many as you like for each chosen subject.

	subject 1	subject 2	subject 3	subject 4	subject 5	subject 6
Enjoyment of subject at "*Standard Grade*"						
Good grades at school in subject						
Interest in subject						
Your teacher at school						
Your parents						
Information from mass media						
Friends						
Career opportunities						
Demonstrations, exhibitions, festivals						
It is a good basis for other subjects						
Any other factor(s) (*please indicate*)						

11. Are you thinking of going to the **University** after school?

☐ Yes ☐ No ☐ Don't know yet

The questions 12-15 are only for those who answered "Yes" in Question 11.

12. Why are you going to **enter University** after school?
Tick as many as you like.

☐ want to continue study (*what subject, if known)* ....
☐ get away from home
☐ normal thing to do after finishing school
☐ I feel it is expected from me, (*by whom?*) ....
☐ interesting job in future
☐ social pressure and norms
☐ interest in subject(s), (*what subject(s), if known*)..
☐ to become a specialist, (*which one?*)..
☐ my teacher suggests it for me

13. Do you know already which University would you prefer to enter?

☐ Yes (indicate, please)... .... ☐ No

14. If you answer "No", GO TO the Question 15.
If you answer "Yes", could you indicate why would you like to enter this particular University?
Tick as many as you like.

☐ It has a good academic reputation
☐ It is near my home
☐ It is the best one for subject(s) I want to study
☐ It is the only University which runs the course(s) I want to take
☐ The University seemed to offer excellent extra facilities
☐ My parents suggested to me to enter this University
☐ I was encouraged by demonstrations from this University
☐ I have some friends from this University
☐ any other reason, please indicate ....

15. What are your expectations from the University now? (*e.g. obtain new skills, study the subject deeper, etc..*)..

Thank you very much for answering this questionnaire and all the best in your study!

Centre for Science Education

This questionnaire is a part of a project investigating reasons for studying science subjects.

Please complete as much of the questionnaire as you can.
All information obtained will be treated in complete confidence.

1. Are you: ☐ Male ☐ Female

2. Would you like to do **Physics for Higher Grade** ?

☐ Yes, because..
....
☐ No, because...
....

3. What do you enjoy particularly in your school **Physics lessons**?
Tick as many as you like.

☐ studying the theory
☐ doing practical work in the laboratory
☐ studying about Physics applications in life
☐ explaining natural phenomena
☐ looking at Physics application in social life
☐ problem solving
☐ studying making equipment
☐ doing practical work on computer
☐ studying how Physics can help me in life
☐ other, please indicate..................................
....

4. Why do you find **Physics** interesting?..
....
....

5. To be a **Physicist** is likely to be:
Tick as many as you like.

☐ interesting
☐ hard
☐ enjoyable
☐ stupid
☐ badly paid
☐ not popular
☐ high status
☐ temporary employed
☐ easy employed
☐ well known
☐ stressful
☐ popular
☐ well paid
☐ other, *please identify*........
....

6. To which of the following aspects would you like to be devoted more attention and time in your **Physics lessons**?
Tick as many as you like.

☐ studying the theory deeper
☐ studying more about practical applications of your knowledge
☐ learning about modern developments in Physics
☐ doing more laboratory work
☐ studying about medical applications of Physics
☐ solving Physics tasks on computer
☐ studying more mathematics for Physics
☐ preparing for a career
☐ studying about Physics application in social life
☐ learning about technological processes (e.g. producing electricity in a power station)
☐ studying about environment problems and the way of solving them
☐ learning about modern discoveries in Physics
☐ explaining natural phenomena
☐ learning how technical equipment works (e.g. microwave)
☐ solving different types of problems
☐ other *(please, indicate)*..

Please, turn the page over

This is an example. If you had to describe "a racing car" you could do it like this:

quick	☑ ☐ ☐ ☐ ☐ ☐	*slow*	**The positions of the ticks between the word pairs show that you consider it as very quick, slightly more important than unimportant, and quite dangerous.**
important	☐ ☐ ☑ ☐ ☐ ☐	*unimportant*	
safe	☐ ☐ ☐ ☐ ☑ ☐	*dangerous*	

Use the same method of ticking to answer the questions 7, 8.

7. What are your opinions about your **school lessons** ?

I like Physics lessons	☐ ☐ ☐ ☐ ☐ ☐	I hate Physics lessons
boring lessons	☐ ☐ ☐ ☐ ☐ ☐	interesting lessons
easy lessons	☐ ☐ ☐ ☐ ☐ ☐	complicated lessons
useless lessons	☐ ☐ ☐ ☐ ☐ ☐	important lessons

8. How do you feel yourself about your **school Physics** course?

I feel I am NOT coping well	☐ ☐ ☐ ☐ ☐ ☐	I feel I am coping well
I am growing intellectually	☐ ☐ ☐ ☐ ☐ ☐	I am NOT growing intellectually
I am obtaining a lot of new skills	☐ ☐ ☐ ☐ ☐ ☐	I am NOT obtaining a lot of new skills
I hate practical work	☐ ☐ ☐ ☐ ☐ ☐	I am enjoying practical work
I am getting better in subject	☐ ☐ ☐ ☐ ☐ ☐	I am getting worse in subject
It is definitely "my" subject	☐ ☐ ☐ ☐ ☐ ☐	It is definitely NOT "my" subject

9. What do you like most in your **laboratory work** ?...

....

10. Do you know where people with a **University Degree in Physics** can work?

☐ No, I don't ☐ Doesn't concern me ☐ Yes, I do (*can you give some examples*).......................

....

11. Which of the following topics interest you?
Tick as many as you like.

- ☐ how musical instruments work
- ☐ why we usually have a rainbow after the rain
- ☐ is it safe to use nuclear power for producing electricity
- ☐ how can we increase the power of the car engine
- ☐ how does the telescope work
- ☐ which atmospheric factors influence the weather on the planet
- ☐ why use of X-rays can be harmful for the human body
- ☐ why do we have earthquakes
- ☐ how to construct a simple device to measure the level of radiation
- ☐ how to solve the world food problem
- ☐ how can I earn money by applying my knowledge
- ☐ how to understand the way electrical equipment works
- ☐ what is a black hole in astronomy

12. What do you find most enjoyable in studying **Physics**?..

....

13. Would you like to be a Physicist?

☐ Yes ☐ No ☐ I don't know yet

14. Are you thinking of going to **University** after school?

☐ No ☐ I don't know yet ☐ Yes (indicate the subject(s) you would take at University)..

....

Thank you very much for answering this questionnaire and all the best in your study!

Centre for Science Education

This questionnaire is a part of a project investigating reasons for studying science subjects.

Please complete as much of the questionnaire as you can.
All information obtained will be treated in complete confidence.

1. Are you: ☐ Male ☐ Female

2. Would you like to do Certificate of Six Year Studies **Physics**?

☐ Yes, because..

....

☐ No, because..

....

3. What do you enjoy particularly in your school **Physics lessons**?
Tick as many as you like.

☐ studying the theory
☐ doing practical work in the laboratory
☐ studying about Physics applications in life
☐ explaining natural phenomena
☐ looking at Physics application in social life
☐ problem solving
☐ studying making equipment
☐ doing practical work on computer
☐ studying how Physics can help me in life
☐ other, please indicate..

....

4. Why do you find **Physics** interesting?..

....

....

5. To be a **Physicist** is likely to be:
Tick as many as you like.

☐ interesting
☐ hard
☐ enjoyable
☐ stupid
☐ badly paid
☐ not popular
☐ high status
☐ temporary employed
☐ easy employed
☐ well known
☐ stressful
☐ popular
☐ well paid
☐ other, *please identify*........

....

6. To which of the following aspects would you like to be devoted more attention and time in your **Physics lessons**?
Tick as many as you like.

☐ studying the theory deeper
☐ studying more about practical applications of your knowledge
☐ learning about modern developments in Physics
☐ doing more laboratory work
☐ studying about medical applications of Physics
☐ solving Physics tasks on computer
☐ studying more mathematics for Physics
☐ preparing for a career
☐ studying about Physics application in social life
☐ learning about technological processes (e.g. producing electricity in a power station)
☐ studying about environment problems and the way of solving them
☐ learning about modern discoveries in Physics
☐ explaining natural phenomena
☐ learning how technical equipment works (e.g. microwave)
☐ solving different types of problems
☐ other *(please, indicate)*..

Please, turn the page over

This is an example. If you had to describe "a racing car" you could do it like this:

quick	☑☐☐☐☐☐	*slow*	**The positions of the ticks between the word pairs show that you consider it as very quick, slightly more important than unimportant, and quite dangerous.**
important	☐☐☑☐☐☐	*unimportant*	
safe	☐☐☐☐☑☐	*dangerous*	

Use the same method of ticking to answer the questions 7, 8.

7. What are your opinions about your **school lessons** ?

I like Physics lessons	☐☐☐☐☐☐	I hate Physics lessons
boring lessons	☐☐☐☐☐☐	interesting lessons
easy lessons	☐☐☐☐☐☐	complicated lessons
useless lessons	☐☐☐☐☐☐	important lessons

8. How do you feel yourself about your **school Physics** course?

I feel I am NOT coping well	☐☐☐☐☐☐	I feel I am coping well
I am growing intellectually	☐☐☐☐☐☐	I am NOT growing intellectually
I am obtaining a lot of new skills	☐☐☐☐☐☐	I am NOT obtaining a lot of new skills
I hate practical work	☐☐☐☐☐☐	I am enjoying practical work
I am getting better in subject	☐☐☐☐☐☐	I am getting worse in subject
It is definitely "my" subject	☐☐☐☐☐☐	It is definitely NOT "my" subject

9. What do you like most in your **laboratory work** ?..

....

10. Do you know where people with a **University Degree in Physics** can work?

☐ No, I don't ☐ Doesn't concern me ☐ Yes, I do (*can you give some examples)*........................

....

11. Which of the following topics interest you?
Tick as many as you like.

- ☐ how musical instruments work
- ☐ why we usually have a rainbow after the rain
- ☐ is it safe to use nuclear power for producing electricity
- ☐ how can we increase the power of the car engine
- ☐ how does the telescope work
- ☐ which atmospheric factors influence the weather on the planet
- ☐ why use of X-rays can be harmful for the human body
- ☐ why do we have earthquakes
- ☐ how to construct a simple device to measure the level of radiation
- ☐ how to solve the world food problem
- ☐ how can I earn money by applying my knowledge
- ☐ how to understand the way electrical equipment works
- ☐ what is a black hole in astronomy

12. What do you find most enjoyable in studying **Physics**?..

....

13. Would you like to be a Physicist?

☐ Yes ☐ No ☐ I don't know yet

14. Are you thinking of going to **University** after school?

☐ No ☐ I don't know yet ☐ Yes (indicate the subject(s) you would take at University)..

....

Thank you very much for answering this questionnaire and all the best in your study!

Centre for Science Education

This questionnaire is a part of a project investigating reasons for studying science subjects.

Please complete as much of the questionnaire as you can.
All information obtained will be treated in complete confidence.

1. Are you: ☐ Male ☐ Female

2. What secondary school did you attend ? ....

3. Why did you choose Glasgow University ?
   Tick as many as you like.

   ☐ Only University which offered me a place
   ☐ Best one for subject(s) I wanted to study
   ☐ Only University which runs the course(s) I wanted to take
   ☐ University seemed to offer excellent extra facilities
   ☐ Good academic reputation
   ☐ Near my home
   ☐ No other choices for me
   ☐ Recommended to me

4. What was your intended honours subject(s) when you **first entered** the University?

   ....

5. Which factor(s) influenced your choice of planned **honours** subject(s) ?
   Tick as many as you like.

   ☐ Enjoyment of subject
   ☐ Good grades at school in subject
   ☐ Your teacher at school
   ☐ Your parents
   ☐ Information from mass media
   ☐ Friends
   ☐ Likely career opportunities
   ☐ Demonstrations, exhibitions, festivals
   ☐ Any other factors *(please list below)*

   ....

6. Which subjects are you doing this academic year?

   Subject 1........................ **Subject 2**.......................... **Subject 3**........................

7. Here are some reasons for studying various subjects.
   *Tick as many as you feel are **true for you.***

	Subject 1	Subject 2	Subject 3
This is my degree subject	☐	☐	☐
I am interested in this subject	☐	☐	☐
It is a good basis for studying other subjects	☐	☐	☐
I gained good passes at school in this subject	☐	☐	☐
My adviser suggested the course	☐	☐	☐
I didn't see any alternatives	☐	☐	☐
It leads to good jobs	☐	☐	☐
I enjoy the subject	☐	☐	☐

8. Before coming to Glasgow University, what were your expectations from the Physics course?
   Tick as many as you like.

   1. ☐ developing new or existing skills
   2. ☐ increasing my self-confidence in Physics
   3. ☐ preparing for a career
   4. ☐ experiencing intellectual growth
   5. ☐ having a good time
   6. ☐ deeper understanding of subject
   7. ☐ learning about new ideas
   8. ☐ broadening my horizon
   9. ☐ obtaining practical skills
   10. ☐ meeting new people

9. Have your aspirations in question 8 been fulfilled in your University Physics course?

   ☐ YES (*indicate by the number*) .... ☐ NO (*indicate by number*)........................

Please, turn the page over.

This is an example. If you had to describe "a racing car" you could do it like this:

quick ☐☐☐☐☐☐ *slow*	**The positions of the ticks between the word pairs show that you consider it as <u>very</u> quick, slightly more important than unimportant, and <u>quite</u> dangerous.**
important ☐☐☐☐☐☐ *unimportant*	
safe ☐☐☐☐☐☐ *dangerous*	

Use the same method of ticking to answer the questions 10, 11, 12.

10. What are your opinions about your **<u>school Physics course</u>**?
Place a tick in one box between each phrase to show your opinions.

I liked Physics	☐☐☐☐☐☐	I hated Physics
boring subject	☐☐☐☐☐☐	interesting subject
easy subject	☐☐☐☐☐☐	complicated subject
prepared me well for University	☐☐☐☐☐☐	prepared me badly for University
I dislike the teacher	☐☐☐☐☐☐	I liked the teacher
enjoying lessons	☐☐☐☐☐☐	boring lessons

11. What are your opinions about **<u>University Physics</u>**?
Place a tick in one box between each phrase to show your opinions.

I feel I am coping well	☐☐☐☐☐☐	I feel I am not coping well
I am not enjoying subject	☐☐☐☐☐☐	I am enjoying subject
I found subject is very easy	☐☐☐☐☐☐	I found it hard
I am growing intellectually	☐☐☐☐☐☐	I am not growing intellectually
I am not obtaining new skills	☐☐☐☐☐☐	I am obtaining a lot of new skills
I am enjoying practical work	☐☐☐☐☐☐	I hate practical work
I am getting worse at the subject	☐☐☐☐☐☐	I am getting better at the subject
It is definitely "my" subject	☐☐☐☐☐☐	I am wasting my time in this subject

12. How did you find the **<u>Physics course at the University</u>** ?
Place a tick in one box between each phrase to show your opinions.

Lectures boring	☐☐☐☐☐☐	Lectures interesting
Laboratories interesting	☐☐☐☐☐☐	Laboratories boring
Tutorials helpful	☐☐☐☐☐☐	Tutorials waste of time
Course too mathematical	☐☐☐☐☐☐	Course not mathematical enough
Course difficult	☐☐☐☐☐☐	Course easy
Work level very demanding	☐☐☐☐☐☐	Work level undemanding

- -

13. Are you thinking of changing your planned **honours** degree subject(s) since you came to university ?

☐ NO ☐ YES (*Please, indicate which subject you are considering for Degree now)*

....

14. Thinking about your **Physics course**, tick the boxes below to reflect your opinions

	Strongly agree	Agree	Disagree	Strongly disagree
I found the course well organised	☐	☐	☐	☐
I felt the assessment methods used were good	☐	☐	☐	☐
The time demand was NOT reasonable for me	☐	☐	☐	☐
I found a good support from the academic staff	☐	☐	☐	☐
I think there will be poor career opportunities	☐	☐	☐	☐

15. At the moment, do you hope to study Physics at level 2 ?

☐ YES ☐ NO

Please give a reason for your answer: ....

....

Thank you very much for your cooperation!

Centre for Science Education

This questionnaire is a part of a project investigating reasons for studying science subjects.

Please complete as much of the questionnaire as you can.
All information obtained will be treated in complete confidence.

1. Are you: ☐ Male ☐ Female

2. Would you like to do a **Physics Degree** (Single or Combined Honours)?

☐ Yes, because..
....
☐ No, because..
....

3. What do you enjoy particularly in your University **Physics course**?
Tick as many as you like.

☐ studying the theory
☐ doing practical work in the laboratory
☐ studying about Physics applications in life
☐ explaining natural phenomena
☐ looking at Physics application in social life
☐ problem solving
☐ analysing data on a computer
☐ studying how Physics can help me in life
☐ other, please indicate ....
....

4. Why do you find **Physics** interesting?...
....
....

5. To be a **Physicist** is likely to be:
Tick as many as you like.

☐ interesting
☐ hard
☐ enjoyable
☐ stupid
☐ badly paid
☐ not popular
☐ high status
☐ temporary employed
☐ easy employed
☐ well known
☐ stressful
☐ popular
☐ well paid
☐ other, *please identify........*
....

6. To which of the following aspects would you like to be devoted more attention and time in your **Physics course**?
Tick as many as you like.

☐ studying the theory deeper
☐ studying more about practical applications of your knowledge
☐ learning about modern developments in Physics
☐ doing more laboratory work
☐ studying about medical applications of Physics
☐ doing computer simulations of Physics tasks
☐ studying more mathematics for Physics
☐ preparing for a career
☐ studying about Physics application in social life
☐ learning about technological processes
☐ studying about environmental problems and the way of solving them
☐ learning about modern discoveries in Physics
☐ explaining natural phenomena
☐ learning how technical equipment works
☐ solving different types of problems
☐ other *(please, indicate)*..

Please, turn the page over

7. What do you like most in your **laboratory work** ?..

....

8. What features of the **laboratory practise** would you like to be changed? ....

....

9. Which of the following topics interest you?

Tick as many as you like.

- ☐ What kind of trajectory has a comet and how this can be explained?
- ☐ If time is relative can we ever travel backward in time?
- ☐ How does a TV remote control work?
- ☐ What is the origin of the earth magnetic field?
- ☐ What are the advantages of optical communications?
- ☐ What is the Physics behind an invisible aircraft?
- ☐ Will quarks ever be detected?
- ☐ If it be proved that neutrinos has a mass would it change the theory of a Big Bang?
- ☐ How much energy and money can we save by improving insulation of our homes?
- ☐ Why can't we reach the temperature of Absolute Zero?
- ☐ How to appreciate the size of a molecule using every day tools?
- ☐ Why matter dominate over antimatter?

10. What do you find most enjoyable in studying **Physics**?..

....

11. Do you know where people with a **University Degree in Physics** can work?

☐ No, I don't ☐ Doesn't concern me ☐ Yes, [illegible] *you give some examples)*......................

....

12. Would you like to be a **Physicist**?

☐ Yes ☐ No ☐ I don't know yet

13. Where would you prefer to follow your career?

☐ business	☐ own business
☐ charity	☐ craft
☐ research	☐ social work
☐ industry	☐ teaching
☐ lecturing	☐ other, please indicate..
☐ medicine	....

14. What is your most exciting experience in University **Physics course?**......................................

....

....

15. What changes or improvements would you like to see made to **University Physics** course?......

....

....

Willingness to help again. *We would like to interview a group of students about your view of Physics laboratory practice next term. If you are willing to help (~ 30 min, refreshments provided) please, leave your name* ....

Thank you very much for answering this questionnaire and all the best in your study!

Level 1, May 1998

Centre for Science Education

This questionnaire is a part of a project investigating reasons for studying science subjects.

Please complete as much of the questionnaire as you can.
All information obtained will be treated in complete confidence.

1. Are you: ☐ Male ☐ Female

2. What secondary school did you attend ? ....

3. Are you going to do **Physics** for Degree?

   ☐ Yes ☐ No (*please, indicate your proposed Degree subject*).....................................

4. What do you enjoy particularly in your University **Physics** course ?
   Tick as many as you like.

   ☐ studying the theory
   ☐ doing practical work in the laboratory
   ☐ studying about Physics applications in life
   ☐ problem solving
   ☐ studying making equipment
   ☐ doing practical work on computer
   ☐ other, *please indicate*..

5. Do you know where people with a **Degree in Physics** can work?

   ☐ No, I don't ☐ Doesn't concern me ☐ Yes, I do (*can you give some examples*).......................

   ....

6. To be a **Physicist** is likely to be:
   Tick as many as you like.

   ☐ interesting
   ☐ hard
   ☐ enjoyable
   ☐ stupid
   ☐ badly paid
   ☐ not popular
   ☐ prestigious
   ☐ always on temporary contracts
   ☐ easy employed
   ☐ well known
   ☐ stressful
   ☐ popular
   ☐ well paid
   ☐ other, *please identify*........
   ....

7. To which of the following aspects would you like to be devoted more attention and time in your **Physics** course?
   Tick as many as you like.

   ☐ studying the theory deeper
   ☐ studying more about practical application of your knowledge
   ☐ learning about modern perspectives of Physics science development
   ☐ doing laboratory practice
   ☐ studying about medical application of Physics
   ☐ doing computer simulations of Physics tasks
   ☐ studying more mathematics for Physics
   ☐ preparing for the career
   ☐ studying about Physics application in social life
   ☐ studying about environment problems and the way of solving them
   ☐ learning about modern discoveries in Physics
   ☐ other (*please, indicate*)..

8. In Physics 1X and 1Y, did you feel that **your time** was used profitably?
   Please, give your scores: 1 is bad, 5 is good.

Lectures;	*1*	*2*	*3*	*4*	*5*
Optics, waves and lasers					
Thermal Physics					
Dynamics and relativity					
Thermal and mechanical properties of matters					
Electricity, electronics and magnetism					
Quantum Phenomena					
Laboratories;					
Accelerated motion					
Optics					
The Spectrometer					
e/m for electron					
Thermal radiation					
Operational Amplifiers					

Please turn the page over

9. Please tick an appropriate box which indicates your opinion about the **Physics topics**:

Easy	understood without difficulties
Moderate	had difficulties but I understand it now
Difficult	still do not understand it

	Easy	Moderate	Difficult	If difficult, please say why
Huygen's principle	☐	☐	☐	....
Conservative forces	☐	☐	☐	....
Black body	☐	☐	☐	....
Kinetic theory of ideal gas	☐	☐	☐	....
Pauli exclusion principle	☐	☐	☐	....
Magnetic field and magnetic flux	☐	☐	☐	....
Mirror and lens equations	☐	☐	☐	....
Ideal gas	☐	☐	☐	....
Hook's law	☐	☐	☐	....
Incompressible fluid	☐	☐	☐	....
Inertial and rest frames of reference	☐	☐	☐	....
Rutherford model of nuclear atom	☐	☐	☐	....
Motion of rotating bodies	☐	☐	☐	....
Linear superposition of waves	☐	☐	☐	....
Stefan-Boltzman Law	☐	☐	☐	....
Stress and strain	☐	☐	☐	....
Ampere's Law	☐	☐	☐	....
Equation of state	☐	☐	☐	....
Heisenberg uncertainty relationships	☐	☐	☐	....
Coherent and incoherent light	☐	☐	☐	....
Lorentz transformation equation	☐	☐	☐	....
Simple harmonic motion	☐	☐	☐	....
Bohr model	☐	☐	☐	....
Work-energy theorem	☐	☐	☐	....
Couloumb's Law	☐	☐	☐	....
Linear momentum	☐	☐	☐	....
Bernouilli's equation	☐	☐	☐	....
Time dilation and space contraction	☐	☐	☐	....
Ohm's Law	☐	☐	☐	....
Interference and diffraction	☐	☐	☐	....
Van der Waal's equation	☐	☐	☐	....
Angular momentum	☐	☐	☐	....
Quarks	☐	☐	☐	....

What do you think needs to be done to improve the first year **Physics course**?
Please, write down your suggestions below;

....

....

....

....

Thank you for answering this questionnaire and all success in your study.

Centre for Science Education

This questionnaire is a part of a project investigating reasons for studying science subjects.

Please complete as much of the questionnaire as you can.
All information obtained will be treated in complete confidence.

1. Are you: ☐ Male ☐ Female

2. What secondary school did you attend ? ....

3. Are you going to do Physics for Degree?

   ☐ Yes ☐ No (*please, indicate your proposed Degree subject*)......................................

4. What do you enjoy particularly in your University **Physics course** ?
   Tick as many as you like.

   ☐ studying the theory
   ☐ doing practical work in the laboratory
   ☐ studying about Physics applications in life
   ☐ problem solving
   ☐ studying making equipment
   ☐ doing practical work on computer
   ☐ else, please indicate..

5. Do you know where people with a **Degree in Physics** can work?
   ☐ No, I don't ☐ Doesn't concern me ☐ Yes, I do (*can you give some examples*).......................
   ....

6. To be a **Physicist** is likely to be:
   Tick as many as you like.

   ☐ interesting
   ☐ hard
   ☐ enjoyable
   ☐ stupid
   ☐ badly paid
   ☐ not popular
   ☐ prestigious
   ☐ always on temporary contracts
   ☐ easy employed
   ☐ well known
   ☐ stressful
   ☐ popular
   ☐ well paid
   ☐ else, *please identify*..........
   ....

7. To which of the following aspects would you like to be devoted more attention and time in your **Physics course**?
   Tick as many as you like.

   ☐ studying the theory deeper
   ☐ studying more about practical application of your knowledge
   ☐ learning about modern perspectives of Physics science development
   ☐ doing laboratory practice
   ☐ studying about medical application of Physics
   ☐ doing computer simulations of Physics tasks
   ☐ studying more mathematics for Physics
   ☐ preparing for the career
   ☐ studying about Physics application in social life
   ☐ studying about environment problems and the way of solving them
   ☐ learning about modern discoveries in Physics
   ☐ other (*please, indicate*)..

8. In Physics 2X and 2Y, did you feel that **your time** was used profitably?
   Please, give your scores: 1 is bad, 5 is good.

	1	2	3	4	5
Rotation, gravity and planetary motion..................					
The Physics of Chance..................					
The Nucleus & Radioactive decay..................					
Microscopic Thermal Physics..................					
Oscillatory Mechanical system..................					
Oscillatory Electrical systems..................					
Classical and Quantum waves..................					
Optical systems..................					
Diffraction from crystals, non-linear behaviour.......					
Laboratories					

Please turn the page over

9. Please tick an appropriate box which indicates your opinion about the **Physics topics**:

Easy	understood without difficulties
Moderate	had difficulties but I understand it now
Difficult	still do not understand it

	Easy	Moderate	Difficult	If difficult, please say why
Fourier analysis	☐	☐	☐	....
Entropy and disorder	☐	☐	☐	....
Resonance	☐	☐	☐	....
Angular velocity and acceleration	☐	☐	☐	....
Rutherford scattering	☐	☐	☐	....
Conservative forces	☐	☐	☐	....
Mean, standard deviation	☐	☐	☐	....
Maxwell-Bolzman distribution	☐	☐	☐	....
Differential of complex functions	☐	☐	☐	....
Bragg Law for diffraction	☐	☐	☐	....
Phase and group velocity	☐	☐	☐	....
Faraday's Law	☐	☐	☐	....
First Law of Thermodynamic	☐	☐	☐	....
Gaussian distribution	☐	☐	☐	....
Angular momentum, torque	☐	☐	☐	....
Schrodinger wave equation	☐	☐	☐	....
Critical mass	☐	☐	☐	....
Second Law of Thermodynamics	☐	☐	☐	....
Reduced mass	☐	☐	☐	....
Law of radioactive decay	☐	☐	☐	....
Complex number	☐	☐	☐	....
Gauss's Law of electrostatics	☐	☐	☐	....
Thermodynamic equilibrium	☐	☐	☐	....
Fresnel diffraction	☐	☐	☐	....
Binomial distribution	☐	☐	☐	....
De Broglie wavelength	☐	☐	☐	....
Radiation	☐	☐	☐	....
Huygens secondary wavelength	☐	☐	☐	....
Moment of inertia	☐	☐	☐	....
Nuclear force	☐	☐	☐	....
Miller indices	☐	☐	☐	....
Isotopes	☐	☐	☐	....
Chaos	☐	☐	☐	....

What do you think needs to be done to improve the **Physics course**?
Please, write down your suggestions below;

....

....

....

....

Thank you for answering this questionnaire and all success in your study.

Appendix B

Reasons for studying/not studying Physics

S2 students

Reasons for taking Physics for a Standard Grade

I am taking Physics for Standard Grade because:					
	Male (n=78) %	Female (n=49) %	Total (n=127) %	χ^2	significance
I like it	23	24	23	0.02	ns
good grades	8	5	7	-	
Interest in subject	25	34	29	1.20	ns
useful for career	46	40	44	0.44	ns
good basis	9	5	7	-	
important	7	8	7	0.04	ns
useful in life	6	15	9	2.84	ns
better chance to enter university	0	0	0	-	
degree subject	0	0	0	-	
teacher	0	0	0	-	
parents	1	0	1	-	
friends	0	0	0	-	
demonstrations	0	0	0	-	
enjoyable	0	0	0	-	
good higher to have	0	0	0	-	

Reasons for not taking Physics for Standard Grade

	Male (n=83) %	Female (n=85) %	Total (n=168)	χ^2	significance	favoured
Hard	10	22	16	4.48	5%	female
Boring	11	14	13	0.35	-	
Cannot cope	7	13	10	1.68	-	
Do not need	10	25	17	6.52	5%	female
Not good at it	12	4	8	3.67	-	
Do other subject(s)	13	24	18	3.36	-	
Hate it	2	6	4	-	-	
Do not like the teacher	0	0	0	-	-	
Not good at maths.	2	4	3	-	-	
Not interesting	24	45	35	8.18	1%	female
Do not understand it	4	6	5	0.35	-	
Do not want to take it	10	6	8	0.92	-	

Note: df=1
"ns" means "not significant", level of significance is higher than 5%

S3 students

Reasons for taking Physics for a Higher Grade

I am taking Physics for Higher Grade because:						
	Male (n=47) %	Female (n=23) %	Total (n=70) %	χ^2	significance	favoured
I like it	12	4	9	-		
good grades	2	4	3	-		
Interest in subject	29	22	26	0.39	ns	-
useful for career	55	43	51	0.89	ns	-
good basis	36	35	36	0	ns	-
important	7	4	6	-		
useful in life	0	0	0	-		
better chance to enter university	14	9	12	-		
degree subject	7	0	4	-		
teacher	0	0	0	-		
parents	0	0	0	-		
friends	0	0	0	-		
demonstrations	0	0	0	-		
enjoyable	0	0	0	-		
good higher to have	0	0	0	-		

Reasons for not taking Physics for a Higher Grade

	Male (n=20) %	Female (n=8) %	Total (n=28) %	χ^2	significance	favoured
Hard	30	75	43	-		
Boring	10	13	11	-		
Cannot cope	5	13	7	-		
Do not need	5	13	7	-		
Not good at it	10	0	7	-		
Do other subject(s)	0	13	4	-		
Hate it	0	0	0	-		
Do not like the teacher	15	0	11	-		
Not good at maths.	0	0	0	-		
Not interesting	5	25	11	-		
Do not understand it	0	13	4	-		
Do not want to take it	0	13	4	-		

Note: df=1
"ns" means "not significant", level of significance is higher than 5%

S4 students

Reasons for taking Physics for a Higher Grade

I am planning to take Physics for Higher Degree because:					
	Male (n=77) %	Female (n=60) %	Total (n=137) %	χ^2	significance
I like it	75	60	69	3.51	ns
good grades	60	52	56	0.88	ns
Interest in subject	51	37	44	2.67	ns
useful for career	26	32	31	0.59	ns
good basis	7	15	10	2.30	ns
important	11	3	8	-	-
useful in life	4	12	7	-	-
better chance to enter university	4	3	3	-	-
degree subject	2	0	1	-	-
teacher	4	12	7	-	-
parents	2	9	5	-	-
friends	2	3	2	-	-
demonstrations	0	0	0	-	-
enjoyable	7	12	9	1.01	ns
good higher to have	4	9	6	-	-

Reasons for not taking Physics for a Higher Grade

	Male (n=10)	Female (n=5)	Total, (n=15)
Prefer another subject	10	0	7
Boring	30	40	33
Cannot cope	10	0	7
Do not like	10	0	7
Too complicated	10	20	13
Not interesting	10	0	7
Leaving school	20	20	20
Do not need it	10	20	13
Do not enjoy the depth	0	0	0
Teacher	0	0	0
Do not understand	0	0	0

Note: df=1
"ns" means "not significant", level of significance is higher than 5%

***P1Y - 1998/9** – level 1 university Physics students*

Reasons for taking Physics for Honours

I am doing Physics for a Degree, because (%):			
	Male, (n=30)	Female, (n=10)	Total, (n=40)
easy employed	0	0	0
career opportunities	17	20	18
Interesting*	47	60	50
well respected Degree	3	0	3
stimulating	3	0	3
enjoyable	13	10	13
I am good at it	7	0	5
useful for society	3	0	3
no explanations	0	40	10
no better options	3	0	3

Note: * χ^2 =0.51 not significant when df=1

Reasons for not taking Physics for Honours

I do not want to continue Physics for a Degree because (%):			
	Male, (n=19)	Female, (n=5)	Total, (n=24)
prefer another subject	37	20	33
course is bad	5	0	4
cannot cope	0	20	4
Do not like	5	20	8
too complicated	21	20	21
boring	21	0	17
labs waste of time	16	20	17
not interesting	11	20	13

Note: no difference between male and females wads obtained

***P2Y- 1998/99** – level 2 university Physics students:*

Reasons for taking Physics for Honours:

I am doing Physics for a Degree because (%);			
	Male, (n=23)	Female, (n=9)	Total, (n=32)
easy employed	0	33	9
career opportunities	30	33	31
interesting	43	33	41
well respected Degree	0	33	9
stimulating	0	11	3
enjoyable	4	0	3
I am good at it	13	11	13
useful for society	0	0	0
no explanations	0	0	0
no better options	4	0	3

Reasons for not taking Physics for Honours:

I do not want to continue studying Physics for a Degree because (%):			
	Male, (n=2)	Female, (n=0)	Total, (n=2)
prefer another subject	50	0	50
course is bad	50	0	50
cannot cope	0	0	0
do not like it	0	0	0
too complicated	0	0	0
boring	0	0	0
labs waste of time	0	0	0
not interesting	0	0	0

Note: no difference between male and females wads obtained

Appendix C

Pupils' attitudes towards Science/Physics lessons

Primary pupils

What are your opinions about your **school science lessons**?

I like science lessons ▢ ▢ ▢ ▢ ▢ ▢ I hate science lessons
boring lessons ▢ ▢ ▢ ▢ ▢ ▢ interesting lessons
I enjoy the lessons ▢ ▢ ▢ ▢ ▢ ▢ I do not enjoy the lessons
easy lessons ▢ ▢ ▢ ▢ ▢ ▢ complicated lessons

Primary P6/P7 : Girls (N= 68)
Boys (N= 74)

	positive %	**neutral %**	**negative %**	χ^2	df
group/ statements	I like science lessons	▭	I hate science lessons		
Girls	66	34	0		
Boys	72	19	9	0.59	1
	interesting lessons	▭	boring lessons		
Girls	57	40	3		
Boys	70	18	12	10.68**	2
	easy lessons	▭	difficult lessons		
Girls	25	53	22		
Boys	36	38	26	3.40	2
	I enjoy the lessons		I do not enjoy the lessons		
Girls	69	31	0		
Boys	64	24	12	0.22	1
	important subject	▭	useless subject		
Girls	76	18	1		
Boys	70	22	8	0.44	1

** means significance at 1% level of probability

note: in some cases df=1 , but in some df=2. The lower degree of freedom is used to avoid frequencies less then 4, in such cases the positive and negative frequencies were compared.

S2 pupils

What are your opinions about your **science lessons**?

I like science lessons	▢ ▢ ▢ ▢ ▢ ▢	I hate science lessons
boring lessons	▢ ▢ ▢ ▢ ▢ ▢	interesting lessons
easy lessons	▢ ▢ ▢ ▢ ▢ ▢	complicated lessons
I'd like to spend less time on it	▢ ▢ ▢ ▢ ▢ ▢	I'd like to spend more time on science
useless lessons	▢ ▢ ▢ ▢ ▢ ▢	important lessons
enjoying lessons	▢ ▢ ▢ ▢ ▢ ▢	boring lessons

S2 : Girls (N = 194)
Boys (N=189)

	positive %	**neutral %**	**negative %**	χ^2	df
group/ statements	I like science lessons	▭	I hate science lessons		
Girls	45	42	13		
Boys	61	34	5	13.01**	2
	interesting lessons	▭	boring lessons		
Girls	38	44	18		
Boys	41	51	8	8.54*	2
	easy lessons	▭	complicated lessons		
Girls	22	65	13		
Boys	22	63	15	0.33	
	I'd like to spend more time on science	▭	I'd like to spend less time on it		
Girls	18	52	30		
Boys	28	56	16	12.58**	2
	important lessons	▭	useless lessons		
Girls	49	40	11		
Boys	57	37	6	4.19	2
	enjoying lessons	▭	boring lessons		
Girls	40	47	13		
Boys	52	40	8	6.35*	1

** means significance at 1% level of probability
* means significance at 5% level of probability

note: in some cases df=1 , but in some df=2. The lower degree of freedom is used to avoid frequencies less then 4, in such cases the positive and negative frequencies were compared.

S3 pupils

What are your opinions about your **Physics lessons**?

I like Physics lessons	☐ ☐ ☐ ☐ ☐ ☐	I hate Physics lessons
boring lessons	☐ ☐ ☐ ☐ ☐ ☐	interesting lessons
easy lessons	☐ ☐ ☐ ☐ ☐ ☐	complicated lessons
useless lessons	☐ ☐ ☐ ☐ ☐ ☐	important lessons
enjoying lessons	☐ ☐ ☐ ☐ ☐ ☐	boring lessons

S3 : Girls (N = 34)
Boys (N = 69)

	positive %	neutral %	negative %	χ^2	df
group/ statements	I like Physics lessons	☐	I hate Physics lessons		
Girls	42	51	7		
Boys	54	32	14	3.16	2
	interesting lessons	☐	boring lessons		
Girls	35	48	17		
Boys	38	50	12	0.49	2
	easy lessons	☐	complicated lessons		
Girls	2	64	34		
Boys	22	57	21	7.63*	2
	important lessons	☐	useless lessons		
Girls	54	46	0		
Boys	62	29	9	1.89	1
	enjoying lessons	☐	boring lessons		
Girls	36	45	19		
Boys	46	23	21	3.85	2

* means significance at 5% level of probability

note: in some cases df=1 , but in some df=2. The lower degree of freedom is used to avoid frequencies less then 4, in such cases the positive and negative frequencies were compared.

S4 pupils

What are your opinions about your **Physics lessons**?

I like Physics lessons □ □ □ □ □ □ I hate Physics lessons
boring lessons □ □ □ □ □ □ interesting lessons
easy lessons □ □ □ □ □ □ complicated lessons
useless lessons □ □ □ □ □ □ important lessons
enjoying lessons □ □ □ □ □ □ boring lessons

S4 : Girls (N=65)
Boys (N=87)

	positive %	**neutral %**	**negative %**	χ^2	df
group/ statements	I like Physics lessons	□	I hate Physics lessons		
Girls	56	32	12		
Boys	55	38	6	1.94	2
	interesting lessons	□	boring lessons		
Girls	56	36	8		
Boys	47	47	6	1.87	2
	easy lessons	□	complicated lessons		
Girls	8	68	24		
Boys	9	67	26	0.09	2
	important lessons	□	useless lessons		
Girls	68	32	0		
Boys	77	23	0	1.54	1
	enjoying lessons	□	boring lessons		
Girls	60	40	0		
Boys	51	34	13	1.22	1

note: in some cases df=1 , but in some df=2. The lower degree of freedom is used to avoid frequencies less then 4, in such cases the positive and negative frequencies were compared.

S5/S6 pupils

What are your opinions about your **Physics lessons**?

I like Physics lessons	☐ ☐ ☐ ☐ ☐ ☐	I hate Physics lessons
boring lessons	☐ ☐ ☐ ☐ ☐ ☐	interesting lessons
easy lessons	☐ ☐ ☐ ☐ ☐ ☐	complicated lessons
useless lessons	☐ ☐ ☐ ☐ ☐ ☐	important lessons
enjoying lessons	☐ ☐ ☐ ☐ ☐ ☐	boring lessons

S5/S6 : Girls (N=28)
Boys (N=68)

	positive %	**neutral %**	**negative %**	χ^2	df
group/ statements	I liked Physics lessons	☐	I hated Physics lessons		
Girls	44	44	11		
Boys	34	61	5	0.85	1
	interesting lessons	☐	boring lessons		
Girls	33	56	11		
Boys	26	58	26	2.33	2
	easy lessons	☐	difficult lessons		
Girls	17	56	28		
Boys	11	55	34	0.78	2
	important lessons	☐	useless lessons		
Girls	33	67	0		
Boys	42	55	3	0.80	1
	enjoying lessons	☐	boring lessons		
Girls	25	61	12		
Boys	23	53	24	1.66	2

note: in some cases df=1 , but in some df=2. The lower degree of freedom is used to avoid frequencies less then 4, in such cases the positive and negative frequencies were compared.

What are your opinions about your **science/Physics lessons**?

Total : Primary (N=142)
S2 (N=383
S3 (N=103)
S4 (N=152)
S5/S6 (N= 96)

	positive %	**neutral %**	**negative %**		
group/ statements	I like science/Physics lessons	▭	I hate science/Physics lessons	χ^2	df
Primary P6/P7	69	26	5		
S2	52	38	10	12.57**	2
S3	54	36	10		
S4	55	36	8	0.28	2
S4	55	36	8		
S5/S6	38	55	7	8.46*	2
	interesting lessons	▭	boring lessons		
Primary P6/P7	64	28	8		
S2	38	49	13	28.31**	2
S3	42	47	11		
S4	50	43	7	2.20	2
S4	50	43	7		
S5/S6	29	57	14	11.55**	2
	easy lessons	▭	complicated lessons		
Primary P6/P7	31	45	24		
S2	23	63	14	14.61*	2
S3	16	52	22		
S4	9	67	25	4.38	2
S4	9	67	25		
S5/S6	13	55	32	3.29	2
	important lessons	▭	useless lessons		
Primary P6/P7♣	70	20	5		
S2	63	29	8	5.11	2
S3	63	34	3		
S4	74	26	0	3.51	1
S4	74	26	0		
S5/S6	39	59	2	30.15**	1
	enjoying lessons		boring lessons		
Primary P6/P7	66	27	6		
S2	45	44	11	19.38**	2

S3	47	40	13		
S4	54	36	8	2.35	2
S4	54	36	8		
S5/S6	31	53	16	14.20**	2

** means significance at 1% level of probability
* means significance at 5% level of probability

♣ means "important subject " for P6/P7 pupils

note: in some cases df=1 , but in some df=2. The lower degree of freedom is used to avoid frequencies less then 4, in such cases the positive and negative frequencies were compared.

Appendix D

Pupils' perceptions of self in Science/Physics lessons

P6/P7 pupils

How do you feel yourself in your science course at school?

I feel I am coping well	☐ ☐ ☐ ☐ ☐ ☐	I feel I am NOT coping well
I learn a lot of new	☐ ☐ ☐ ☐ ☐ ☐	I learn nothing new in science lessons
I am NOT obtaining new skills	☐ ☐ ☐ ☐ ☐ ☐	I am obtaining a lot of new skills
I hate doing experiments	☐ ☐ ☐ ☐ ☐ ☐	I am enjoying doing experiments
I like the teacher	☐ ☐ ☐ ☐ ☐ ☐	I dislike the teacher
Science is important subject	☐ ☐ ☐ ☐ ☐ ☐	Science is unimportant subject

Primary P6/P7: Boys(N= 74)
Girls (N= 68)

	positive %	neutral %	negative %		
groups/ statements	I feel I am coping well	☐	I feel I am not coping well	χ^2	df
Girls	69	26	1		
Boys	77	20	3	0.48	1
	I learn a lot of new	☐	I learn nothing new in science lessons		
Girls	90	6	1		
Boys	74	20	5	8.11**	1
	I am obtaining a lot of new skills	☐	I am NOT obtaining new skills		
Girls	69	22	6		
Boys	58	34	8	2.66	2
	I am enjoying doing experiments	☐	I hate doing experiments		
Girls	85	9	3		
Boys	84	9	7	0.73	2
	I like the teacher	☐	I dislike the teacher		
Girls	62	26	4		
Boys	62	23	15	4.32	2
	Science is important subject	☐	Science is unimportant subject		
Girls	76	18	1		
Boys	70	22	8	1.36	1

* means significance at 5% level of probability
** means significance at 1% level of probability

note: in some cases df=1 , but in some df=2. The lower degree of freedom is used to avoid frequencies less then 4, in such cases the positive and negative frequencies were compared.

S2 pupils

How do you feel yourself about your **science course** at school?

I feel I am coping well	☐ ☐ ☐ ☐ ☐ ☐	I feel I am NOT coping well
I am enjoying subject	☐ ☐ ☐ ☐ ☐ ☐	I am NOT enjoying subject
I find it is very hard	☐ ☐ ☐ ☐ ☐ ☐	I find it very easy
I am obtaining a lot of skills	☐ ☐ ☐ ☐ ☐ ☐	I am NOT obtaining new skills
I hate practical work	☐ ☐ ☐ ☐ ☐ ☐	I am enjoying practical work
I like the teacher	☐ ☐ ☐ ☐ ☐ ☐	I dislike the teacher
It is definitely "my" subject	☐ ☐ ☐ ☐ ☐ ☐	It is definitely NOT "my" subject

S2 pupils: Girls (N =194)
Boys (N = 189)

	Positive, %	Neutral, %	Negative, %		
groups/ statements	I feel I am coping well	☐	I feel I am not coping well	χ^2	df
Girls	55	40	5		
Boys	62	29	9	6.35*	2
	I am enjoying subject	☐	I am NOT enjoying subject		
Girls	51	38	11		
Boys	54	37	9	0.57	2
	I find it very hard	☐	I it very easy		
Girls	22	67	11		
Boys	24	62	14	1.23	2
	I am obtaining a lot of new skills	☐	I am not obtaining a lot of new skills		
Girls	46	46	8		
Boys	53	43	4	3.68	2
	I am enjoying practical work	☐	I hate practical work		
Girls	72	19	9		
Boys	51	41	8	22.48**	2
	I like the teacher	☐	I dislike the teacher		
Girls	43	40	17		
Boys	40	48	12	3.25	2
	It is definitely "my" subject	☐	It is definitely NOT "my" subject		
Girls	15	56	29		
Boys	33	53	14	23.12**	2

* means significance at 5% level of probability
** means significance at 1% level of probability

note: in some cases df=1 , but in some df=2. The lower degree of freedom is used to avoid frequencies less then 4, in such cases the positive and negative frequencies were compared.

S3 pupils

I am enjoying subject	□ □ □ □ □ □	I am NOT enjoying subject
I feel I am NOT coping well	□ □ □ □ □ □	I feel I am coping well
I find subject is very easy	□ □ □ □ □ □	I find subject is very hard
I am growing intellectually	□ □ □ □ □ □	I am NOT growing intellectually
am obtaining a lot of new skills	□ □ □ □ □ □	I am NOT obtaining new skills
I hate practical work	□ □ □ □ □ □	I am enjoying practical work
I am getting better in subject	□ □ □ □ □ □	I am getting worse in subject
I dislike the teacher	□ □ □ □ □ □	I like the teacher
It is definitely "my" subject	□ □ □ □ □ □	I am wasting time in this subject

Girls (N= 34), Boys (N= 69)

	Positive, %	**Neutral, %**	**Negative, %**		
groups/ statements	I am enjoying subject	□	I am NOT enjoying subject	χ^2	df
Girls	40	53	7		
Boys	52	40	8	1.58	2
	I feel I am coping well	□	I fell I am not coping well		
Girls	49	38	13		
Boys	55	38	7	1.07	2
	I find subject is very easy	□	I find subject is hard		
Girls	11	57	32		
Boys	17	62	21	1.76	2
	I am growing intellectually	□	I am not growing intellectually		
Girls	28	60	12		
Boys	48	42	10	3.83	2
	I am obtaining a lot of new skills	□	I am not obtaining a lot of new skills		
Girls	35	57	8		
Boys	52	45	3	2.65	1
	I am enjoying practical work	□	I hate practical work		
Girls	75	21	4		
Boys	73	27	0	0.05	1
	I am getting better in the subject	□	I am getting worse in the subject		
Girls	46	46	8		
Boys	54	42	4	1.44	1
	I like the teacher	□	I dislike the teacher		
Girls	50	35	15		
Boys	66	20	14	3.03	2
	It is definitely "my" subject	□	It is definitely not "my" subject		
Girls	22	55	23		
Boys	36	49	15	2.41	2

S4 pupils:

I am enjoying subject	☐ ☐ ☐ ☐ ☐ ☐	I am NOT enjoying subject
I feel I am NOT coping well	☐ ☐ ☐ ☐ ☐ ☐	I feel I am coping well
I find subject is very easy	☐ ☐ ☐ ☐ ☐ ☐	I find subject is very hard
I am growing intellectually	☐ ☐ ☐ ☐ ☐ ☐	I am NOT growing intellectually
I am obtaining a lot of new skills	☐ ☐ ☐ ☐ ☐ ☐	I am NOT obtaining new skills
I hate practical work	☐ ☐ ☐ ☐ ☐ ☐	I am enjoying practical work
I am getting better in subject	☐ ☐ ☐ ☐ ☐ ☐	I am getting worse in subject
It is definitely "my" subject	☐ ☐ ☐ ☐ ☐ ☐	I am wasting time in this subject

Girls (N=65), Boys (N=87)

groups/ statements	Positive, %	Neutral, %	Negative, %	χ^2	df
	I am enjoying subject	☐	I am NOT enjoying subject		
Girls	52	31	17		
Boys	48	32	20	0.31	2
	I feel I am coping well	☐	I fell I am not coping well		
Girls	48	40	12		
Boys	55	38	6	1.95	1
	I find subject is very easy	☐	I find subject is very hard		
Girls	10	80	10		
Boys	15	75	10	0.84	2
	I am growing intellectually	☐	I am not growing intellectually		
Girls	56	40	4		
Boys	49	40	11	0.73	1
	I am obtaining a lot of new skills	☐	I am not obtaining a lot of new skills		
Girls	72	24	4		
Boys	60	29	11	2.36	1
	I am enjoying practical work	☐	I hate practical work		
Girls	76	16	8		
Boys	70	26	4	2.94	2
	I am getting better in the subject	☐	I am getting worse in the subject		
Girls	56	44	0		
Boys	66	34	0	1.58	1
	It is definitely "my" subject	☐	It is definitely not "my" subject		
Girls	24	52	24		
Boys	57	38	4	22.92**	2

** means significance at 1% level of probability

note: in some cases df=1 , but in some df=2. The lower degree of freedom is used to avoid frequencies less then 4, in such cases the positive and negative frequencies were compared.

S5/S6 pupils

I feel I am NOT coping well	☐ ☐ ☐ ☐ ☐ ☐	I feel I am coping well
I am growing intellectually	☐ ☐ ☐ ☐ ☐ ☐	I am NOT growing intellectually
I am obtaining a lot of new skills	☐ ☐ ☐ ☐ ☐ ☐	I am NOT obtaining new skills
I hate practical work	☐ ☐ ☐ ☐ ☐ ☐	I am enjoying practical work
I am getting better in subject	☐ ☐ ☐ ☐ ☐ ☐	I am getting worse in subject
It is definitely "my" subject	☐ ☐ ☐ ☐ ☐ ☐	I am wasting time in this subject

Girls (N=28)
Boys (N=68)

groups/ statements	positive %	neutral %	negative %	χ^2	df
	I feel I am coping well	☐	I fell I am not coping well		
Girls	50	39	11		
Boys	47	29	24	2.32	2
	I am growing intellectually	☐	I am not growing intellectually		
Girls	72	22	6		
Boys	39	50	11	8.64**	1
	I am obtaining a lot of new skills	☐	I am not obtaining a lot of new skills		
Girls	32	61	6		
Boys	32	58	10	0.01	1
	I am enjoying practical work	☐	I hate practical work		
Girls	39	50	11		
Boys	53	45	3	1.45	1
	I am getting better in the subject	☐	I am getting worse in the subject		
Girls	61	39	0		
Boys	53	38	9	0.51	1
	It is definitely "my" subject	☐	It is definitely not "my" subject		
Girls	7	54	39		
Boys	11	58	30	0.58	1

* means significance at 5% level of probability
** means significance at 1% level of probability

note: in some cases df=1 , but in some df=2. The lower degree of freedom is used to avoid frequencies less then 4, in such cases the positive and negative frequencies were compared.

Primary P6/P7 (N=142)
S2 (N=383)
S3 (N=103)
S4 (N=152)
S5/S6 (N= 96)

	positive %	**neutral %**	**negative %**		
groups/ statements	I am enjoying subject		I am NOT enjoying subject	χ^2	df
Primary P6/P7	-	-	-		
S2	51	40	9		
S3	50	43	7		
S4	53	40	7	0.24	2
	I feel I am coping well		I fell I am not coping well		
Primary P6/P7	73	23	2		
S2	58	35	7	13.12**	2
S3	54	39	7		
S4	53	39	8	0.09	2
S4	53	39	8		
S5/S6	48	32	20	7.78*	2
	I find subject is very easy		I find subject is hard		
Primary P6/P7	-	-	-		
S2	24	63	13		
S3	17	58	25		
S4	13	77	10	12.48**	2
S5/S6	-	-	-		
	I am growing intellectually		I am not growing intellectually		
Primary P6/P7	I learn a lot new 82	13	I learn nothing new 4		
S2	-	-	-		
S3	45	48	7		
S4	51	40	8	1.44	2
S4	51	40	8		
S5/S6	50	41	9	0.09	2
	I am obtaining a lot of new skills		I am not obtaining a lot of new skills		

Primary P6/P7	63	28	7		
S2	48	52	0	10.85**	1
S3	53	43	4		
S4	64	28	8	6.84*	2
S4	64	28	8		
S5/S6	32	59	9	25.87**	2
	I am enjoying practical work		I hate practical work		
Primary P6/P7	85	9	5		
S2	60	32	8		
S3	81	15	4		
S4	72	22	6		
S5/S6	48	46	5	51.56	8
	I am getting better in the subject		I am getting worse in the subject		
Primary P6/P7	-	-	-		
S2	-	-	-		
S3	56	39	5		
S4	63	38	0	0.99	1
S4	63	38	0		
S5/S6	55	41	4	1.14	2
	I like the teacher		I dislike the teacher		
Primary P6/P7	62	20	10		
S2	39	45	16	32.22**	2
S3	60	25	15		4
S4	-	-	-		
S5/S6	-	-	-		
	It is definitely "my" subject		It is definitely not "my" subject		
Primary P6/P7	-	-	-		
S2	22	55	23		
S3	34	52	14		
S4	46	43	11	3.68	2
S4	46	43	11		
S5/S6	9	57	34	43.44**	2

* means significance at 5% level of probability
** means significance at 1% level of probability

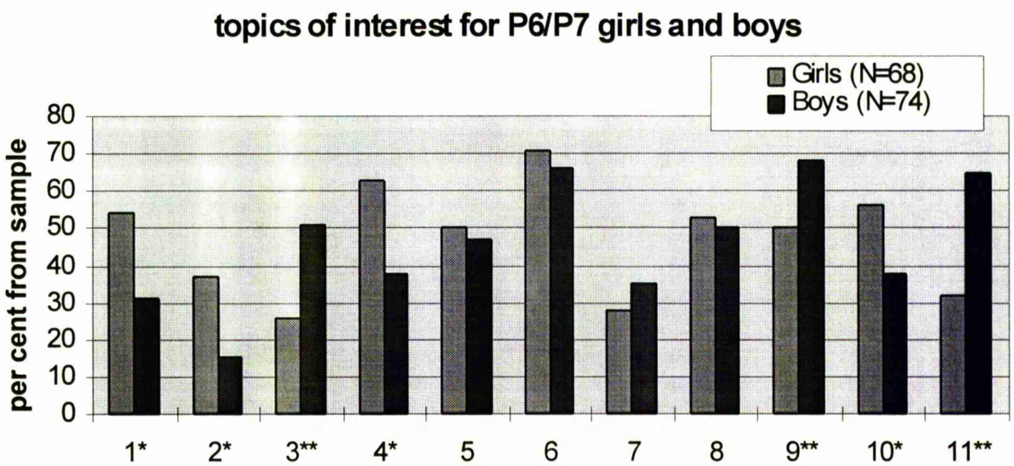
Appendix E

Pupils' interests in Physics topics

P6/P7 pupils' interests in Physics topics

	topics suggested	Girls, % (N=68)	Boys, % (N=74)	χ^2	significance %	favoured
1*	how musical instruments work	54	31	7.69	<0.01	Girls
2*	why we usually have a rainbow after the rain	37	15	9.02	<0.01	Girls
3**	is it safe to use nuclear power for producing electricity	26	51	9.31	<0.01	Boys
4*	why the weather is changing all the time	63	38	8.56	<0.01	Girls
5	why use of X-rays can be harmful for the human body	50	47	0.13	ns	-
6	why do we have earthquakes	71	66	0.41	ns	-
7	how to construct a simple hair dryer	28	35	0.80	ns	-
8	how to solve the world food problem	53	50	0.13	ns	-
9**	how does a TV remote control work	50	68	4.76	<0.05	Boys
10*	why do we have summer, autumn, winter and spring	56	38	4.61	<0.05	Girls
11**	how the power station works	32	65	15.44	<0.00	Boys

Note: df =1 for every case considered
"ns" means "not significant", level of significance is higher than 5%

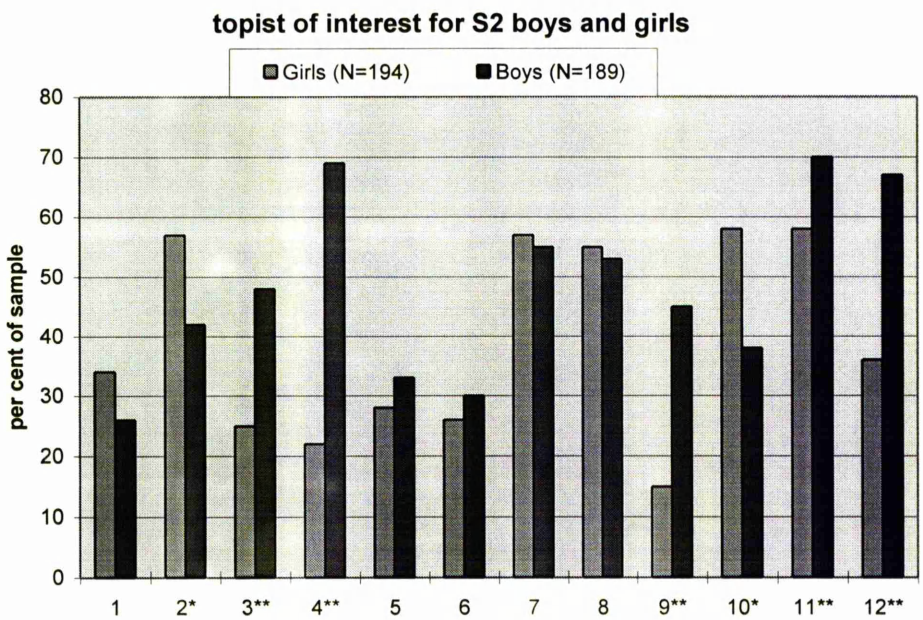


* statistically different interests in favour of girls
** statistically different interests in favour of boys

S2 pupils' interests in Physics topics

	topics suggested	Girls, (N=194) %	Boys, (N=189) %	χ^2	significance %	favoured
1	how musical instrument works	34	26	2.92	ns	-
2*	why we usually have a rainbow after the rain	57	42	8.62	<0.01	Girls
3**	is it safe to use nuclear power for producing electricity	25	48	21.89	<0.01	Boys
4**	how can we increase the power of the car engine	22	69	85.38	<0.00	Boys
5	how does the telescope work	28	33	1.13	ns	-
6	which atmospheric factors influence the weather on the planet	26	30	0.76	ns	-
7	why use of X-rays can be harmful for the human body	57	55	0.16	ns	-
8	why do we have earthquakes	55	53	0.16	ns	-
9**	how to construct the simple device to measure the level of radiation	15	45	41.18	<0.00	Boys
10*	how to solve the world food problem	58	38	15.34	<0.01	Girls
11**	how can I earn money by applying my knowledge	58	70	5.98	<0.05	Boys
12**	how to understand the way electrical equipment work	36	67	36.82	<0.00	Boys

Note: df =1 for every case considered
"ns" means "not significant", level of significance is higher than 5%

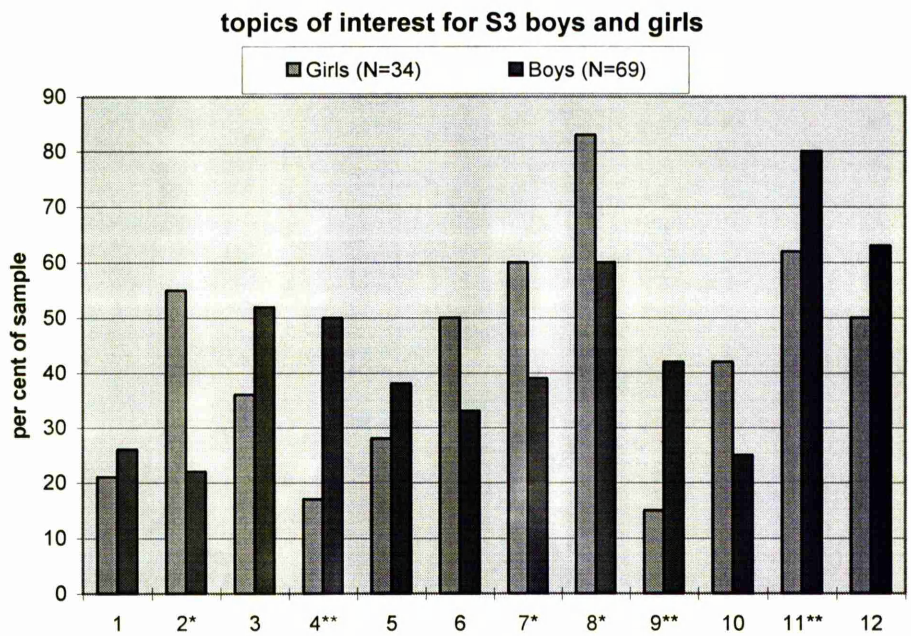


* statistically different interests in favour of girls
** statistically different interests in favour of boys

S3 pupils' interests in Physics topics

	topics suggested	Girls, (N=34) %	Boys, (N=69) %	χ^2	significance %	favoured
1	how musical instrument works	21	26	0.31	ns	-
2*	why we usually have a rainbow after the rain	55	22	11.24	<0.01	Girls
3	is it safe to use nuclear power for producing electricity	36	52	2.34	ns	-
4**	how can we increase the power of the car engine	17	50	10.42	<0.01	Boys
5	how does the telescope work	28	38	1.01	ns	-
6	which atmospheric factors influence the weather on the planet	50	33	2.78	ns	-
7*	why use of X-rays can be harmful for the human body	60	39	4.05	<0.05	Girls
8*	why do we have earthquakes	83	60	5.5	<0.05	Girls
9**	how to construct the simple device to measure the level of radiation	15	42	7.50	<0.01	Boys
10	how to solve the world food problem	42	25	3.10	>0.05	-
11**	how can I earn money by applying my knowledge	62	80	3.84	=0.05	Boys
12	how to understand the way electrical equipment work	50	63	1.59	>0.05	-

Note: df =1 for every case considered
"ns" means "not significant", level of significance is higher than 5%

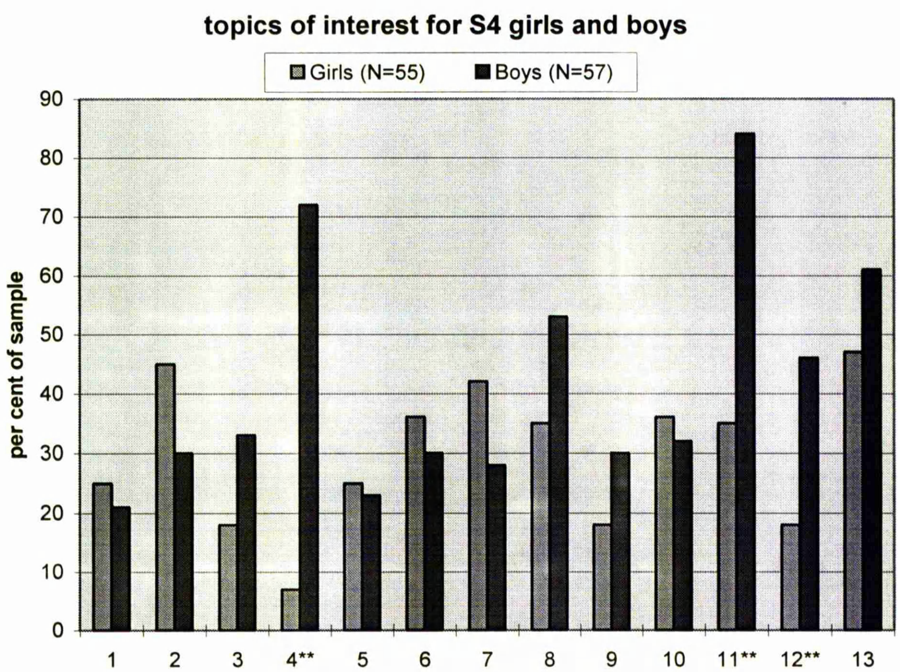


* statistically different interests in favour of girls
** statistically different interests in favour of boys

S4 pupils' interests in Physics topics

	topics suggested	Girls, (N=55) %	Boys, (N=57) %	χ^2	significance %	favoured
1	how musical instrument works	25	21	0.25	ns	-
2	why we usually have a rainbow after the rain	45	30	2.69	ns	-
3	is it safe to use nuclear power for producing electricity	18	33	3.30	ns	-
4**	how can we increase the power of the car engine	7	72	49.24	<0.00	Boys
5	how does the telescope work	25	23	0.06	ns	-
6	which atmospheric factors influence the weather on the planet	36	30	0.46	ns	-
7	why use of X-rays can be harmful for the human body	42	28	2.42	ns	-
8	why do we have earthquakes	35	53	3.68	ns	-
9	how to construct the simple device to measure the level of radiation	18	30	2.20	ns	-
10	how to solve the world food problem	36	32	0.20	ns	-
11**	how can I earn money by applying my knowledge	35	84	27.00	<0.00	Boys
12**	how to understand the way electrical equipment work	18	46	10.04	<0.01	Boys
13	what is black hole in astronomy	47	61	2.21	ns	-

Note: df =1 for every case considered
"ns" means "not significant", level of significance is higher than 5%

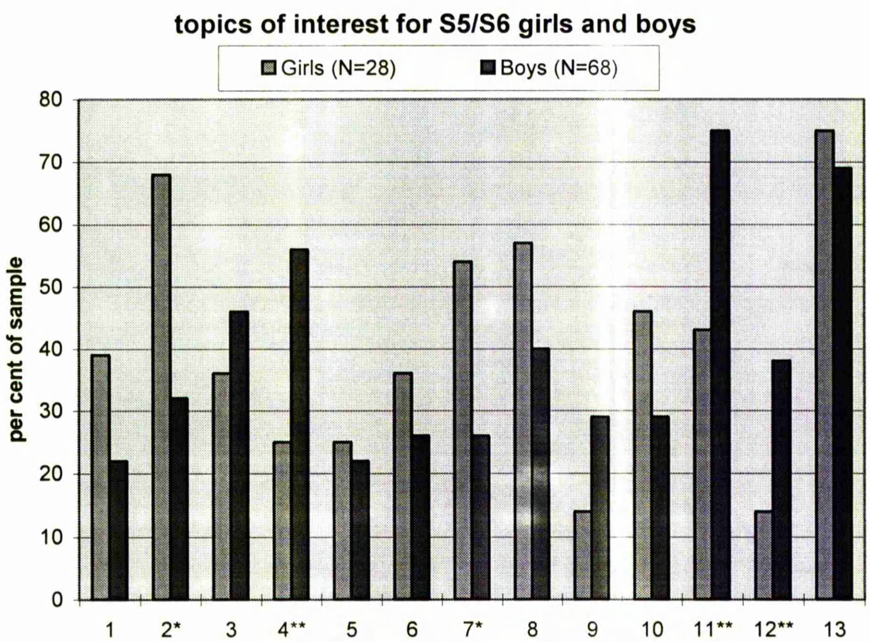


** statistically different interests in favour of boys

S5/S6 pupils' interests in Physics topics

	topics suggested	Girls, (N=28) %	Boys, (N=68) %	χ^2	significance %	favoured
1	how musical instrument works	39	22	2.91	ns	-
2*	why we usually have a rainbow after the rain	68	32	10.52	<0.01	Girls
3	is it safe to use nuclear power for producing electricity	36	46	0.81	ns	-
4**	how can we increase the power of the car engine	25	56	7.65	<0.01	Boys
5	how does the telescope work	25	22	0.10	ns	-
6	which atmospheric factors influence the weather on the planet	36	26	0.95	ns	-
7*	why use of X-rays can be harmful for the human body	54	26	6.91	<0.01	Girls
8	why do we have earthquakes	57	40	2.32	ns	-
9	how to construct the simple device to measure the level of radiation	14	29	2.41	ns	-
10	how to solve the world food problem	46	29	2.56	ns	-
11**	how can I earn money by applying my knowledge	43	75	9.01	<0.01	Boys
12**	how to understand the way electrical equipment work	14	38	5.34	<0.05	Boys
13	what is black hole in astronomy	75	69	0.35	ns	-

Note: df=1 for every case considered
"ns" means "not significant", level of significance is higher than 5%



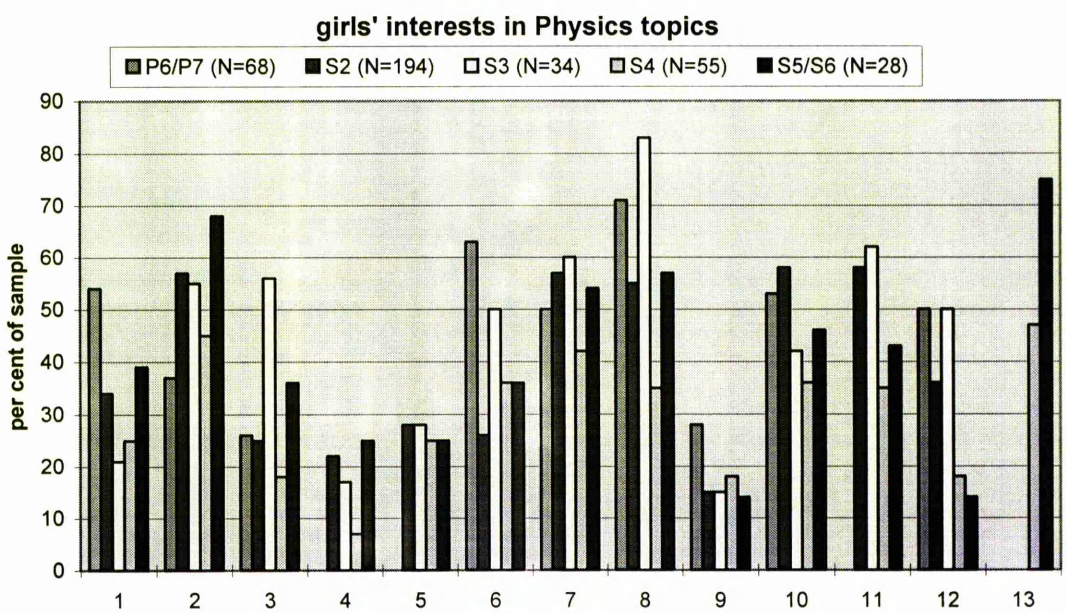
* statistically different interests in favour of girls
** statistically different interests in favour of boys

Comparison of GIRLS' interests in Physics topics (%)

	topics suggested	P6/P7 n=68	S2 N=194	S3 N=34	S4 N=55	S5/S6 N=28
1	how musical instrument works	54	34	21	25	39
2	why we usually have a rainbow after the rain	37	57	55	45	68
3	is it safe to use nuclear power for producing electricity	26	25	56	18	36
4	how can we increase the power of the car engine	-	22	17	7	25
5	how does the telescope work	-	28	28	25	25
6	which atmospheric factors influence the weather on the planet *	63	26	50	36	36
7	why use of X-rays can be harmful for the human body	50	57	60	42	54
8	why do we have earthquakes	71	55	83	35	57
9	how to construct the simple device to measure the level of radiation **	28	15	15	18	14
10	how to solve the world food problem	53	58	42	36	46
11	how can I earn money by applying my knowledge	-	58	62	35	43
12	how to understand the way electrical equipment work ***	50	36	50	18	14
13	what is black hole in astronomy	-	-	-	47	75

- shaded boxes show where girls' interests are significantly higher than boys

* why the weather changing all the time (P6/P7)
** how to construct a simple hair dryer (P6/P7)
*** how does a TV remote control work (P6/P7)

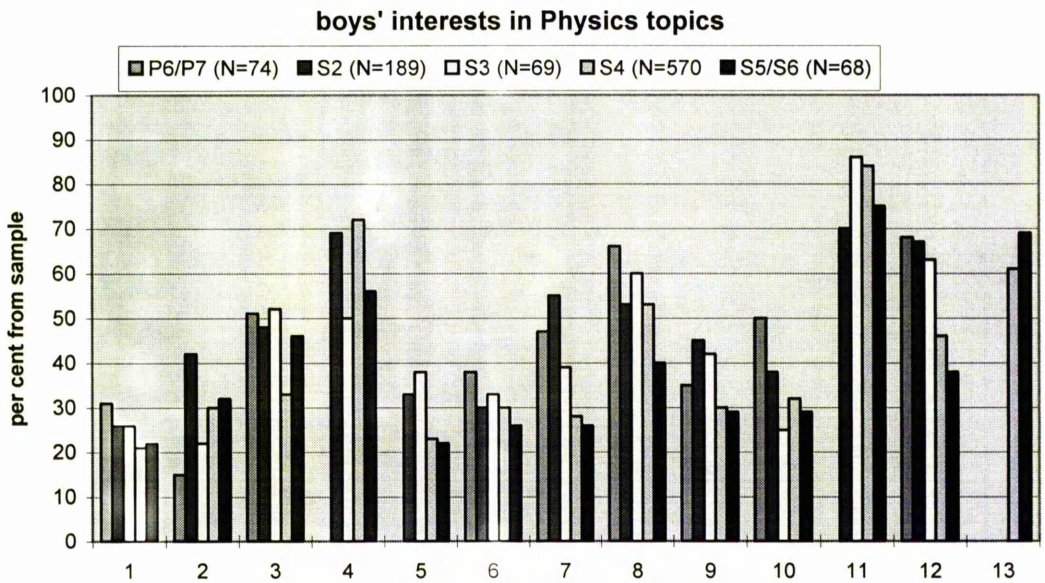


Comparison of BOYS' interests in Physics topics

	topics suggested	**P6/P7 N=74**	**S2 N=189**	**S3 N=69**	**S4 N=57**	**S5/S6 N=68**
1	how musical instrument works	31	26	26	21	22
2	why we usually have a rainbow after the rain	15	42	22	30	32
3	is it safe to use nuclear power for producing electricity	51	48	52	33	46
4	how can we increase the power of the car engine	-	69	50	72	56
5	how does the telescope work	-	33	38	23	22
6	which atmospheric factors influence the weather on the planet *	38	30	33	30	26
7	why use of X-rays can be harmful for the human body	47	55	39	28	26
8	why do we have earthquakes	66	53	60	53	40
9	how to construct the simple device to measure the level of radiation **	35	45	42	30	29
10	how to solve the world food problem	50	38	25	32	29
11	how can I earn money by applying my knowledge	-	70	80	84	75
12	how to understand the way electrical equipment work ***	68	67	63	46	38
13	what is black hole in astronomy	-	-	-	61	69

- shaded boxes show where boys' interests are significantly higher that girls

* why the weather changing all the time (P6/P7)
** how to construct a simple hair dryer (P6/P7)
*** how does a TV remote control work (P6/P7)



Comparison of S3 - S4 - S5/S6 girls' interests in Physics topics

topics suggested	S3 Girls N=34	S4 Girls N=55	S5/S6 Girls N=28	χ^2	significance %	favoured
how musical instrument works	21	25	39	2.76	ns	-
why we usually have a rainbow after the rain	55	45	68	3.99	ns	-
is it safe to use nuclear power for producing electricity	56	18	36	13.76	<0.01	S3
how can we increase the power of the car engine	17	7	25	5.24	ns	-
how does the telescope work	28	25	25	0.11	ns	-
which atmospheric factors influence the weather on the planet	50	36	36	1.97	ns	-
why use of X-rays can be harmful for the human body	60	42	54	2.95	ns	-
why do we have earthquakes	83	35	57	19.62	<0.01	S3
how to construct the simple device to measure the level of radiation	15	18	14	0.27	ns	-
how to solve the world food problem	42	36	46	0.84	ns	-
how can I earn money by applying my knowledge	62	35	43	6.24	-	-
how to understand the way electrical equipment work	50	18	14	13.98	<0.01	S3
what is black hole in astronomy*	-	47	75	5.91	<0.05	S5/S6

- shaded boxes show where girls' interests are significantly higher than boys'

Comparison of S3 - S4 - S5/S6 boys' interests in Physics topics

topics suggested	S3 Boys N=69	S4 Boys N=57	S5/S6 Boys N=68	χ^2	significance %	favoured
how musical instrument works	26	21	22	0.51	ns	-
why we usually have a rainbow after the rain	22	30	32	1.89	ns	-
is it safe to use nuclear power for producing electricity	52	33	46	4.69	ns	-
how can we increase the power of the car engine	50	72	56	6.51	<0.05	S4
how does the telescope work	38	23	22	5.35	ns	-
which atmospheric factors influence the weather on the planet	33	30	26	0.81	ns	-
why use of X-rays can be harmful for the human body	39	28	26	3.08	ns	-
why do we have earthquakes	60	53	40	5.62	ns	-
how to construct the simple device to measure the level of radiation	42	30	29	3.14	ns	-
how to solve the world food problem	25	32	29	0.77	ns	-
how can I earn money by applying my knowledge	80	84	75	3.08	ns	-
how to understand the way electrical equipment work	63	46	38	8.9	<0.05	S3
what is black hole in astronomy*	-	61	69	0.88	ns	-

- shaded boxes show where boys' interests are significantly higher than girls'

Comparison of Standard Grade girls' interests in Physics topics

topics suggested	S3 Girls N=34	S4 Girls N=55	χ^2	significance %	preference
how musical instrument works	21	25	0.19	ns	-
why we usually have a rainbow after the rain	55	45	0.84	ns	-
is it safe to use nuclear power for producing electricity	56	18	13.83	<0.01	S3
how can we increase the power of the car engine	17	7	2.18	ns	-
how does the telescope work	28	25	0.09	ns	-
which atmospheric factors influence the weather on the planet	50	36	1.69	ns	-
why use of X-rays can be harmful for the human body	60	42	2.73	ns	-
why do we have earthquakes	83	35	19.45	<0.00	S3
how to construct the simple device to measure the level of radiation	15	18	0.14	ns	-
how to solve the world food problem	42	36	0.32	ns	-
how can I earn money by applying my knowledge	62	35	6.18	<0.05	S3
how to understand the way electrical equipment work	50	18	10.20	<0.01	S3
what is black hole in astronomy*	-	47	-	-	-

- shaded boxes show where girls' interests are significantly higher than boys'

Comparison of Standard Grade boys' interests in Physics topics

topics suggested	S3 Boys N=69	S4 Boys N=57	χ^2	significance %	preference
how musical instrument works	26	21	0.43	ns	
why we usually have a rainbow after the rain	22	30	1.05	ns	
is it safe to use nuclear power for producing electricity	52	33	4.59	<0.05	S3
how can we increase the power of the car engine	50	72	6.29	<0.05	S4
how does the telescope work	38	23	3.27	ns	
which atmospheric factors influence the weather on the planet	33	30	0.13	ns	
why use of X-rays can be harmful for the human body	39	28	1.68	ns	
why do we have earthquakes	60	53	0.62	ns	
how to construct the simple device to measure the level of radiation	42	30	1.94	ns	
how to solve the world food problem	25	32	0.76	ns	
how can I earn money by applying my knowledge	86	84	0.10	ns	
how to understand the way electrical equipment work	63	46	3.65	ns	
what is black hole in astronomy*	-	61	-		

- shaded boxes show where girls' interests are significantly higher than boys'

Comparison of S4 and S5/S6 girls' interests in Physics topics

topics suggested	S4 Girls N=55	S5/S6 Girls N=28	χ^2	significance %	favoured
how musical instrument works	25	39	1.74	ns	-
why we usually have a rainbow after the rain	45	68	3.94	<0.05	S5/S6
is it safe to use nuclear power for producing electricity	18	36	3.30	ns	-
how can we increase the power of the car engine	7	25	-	-	-
how does the telescope work	25	25	0.00	ns	-
which atmospheric factors influence the weather on the planet	36	36	0.00	ns	-
why use of X-rays can be harmful for the human body	42	54	1.08	ns	-
why do we have earthquakes	35	57	3.68	ns	-
how to construct the simple device to measure the level of radiation	18	14	0.21	ns	-
how to solve the world food problem	36	46	0.78	ns	-
how can I earn money by applying my knowledge	35	43	0.51	ns	-
how to understand the way electrical equipment work	18	14	0.21	ns	-
what is black hole in astronomy*	47	75	5.92	<0.05	S5/S6

- shaded boxes show where girls' interests are significantly higher than boys'

Comparison of S4 - S5/S6 boys' interests in Physics topics

topics suggested	S4 Boys N=57	S5/S6 Boys N=68	χ^2	significance %	favoured
how musical instrument works	21	22	0.02	ns	-
why we usually have a rainbow after the rain	30	32	0.06	ns	-
is it safe to use nuclear power for producing electricity	33	46	2.18	ns	-
how can we increase the power of the car engine	72	56	3.42	ns	-
how does the telescope work	23	22	0.02	ns	-
which atmospheric factors influence the weather on the planet	30	26	0.25	ns	-
why use of X-rays can be harmful for the human body	28	26	0.06	ns	-
why do we have earthquakes	53	40	2.11	ns	-
how to construct the simple device to measure the level of radiation	30	29	0.02	ns	-
how to solve the world food problem	32	29	0.13	ns	-
how can I earn money by applying my knowledge	84	75	1.52	ns	-
how to understand the way electrical equipment work	46	38	0.82	ns	-
what is black hole in astronomy*	61	69	0.88	ns	-

- shaded boxes show where boys' interests are significantly higher than girls'

Comparison of S3 and S5/S6 girls' interests in Physics topics

topics suggested	S3 Girls N=34	S5/S6 Girls N=28	χ^2	significance %	favoured
how musical instrument works	21	39	2.41	ns	-
why we usually have a rainbow after the rain	55	68	1.09	ns	-
is it safe to use nuclear power for producing electricity	56	36	2.47	ns	-
how can we increase the power of the car engine	17	25	0.60	ns	-
how does the telescope work	28	25	0.08	ns	-
which atmospheric factors influence the weather on the planet	50	36	1.22	ns	-
why use of X-rays can be harmful for the human body	60	54	0.23	ns	-
why do we have earthquakes	83	57	5.07	<0.05	S3
how to construct the simple device to measure the level of radiation	15	14	0.01	ns	-
how to solve the world food problem	42	46	0.10	ns	-
how can I earn money by applying my knowledge	62	43	2.23	ns	-
how to understand the way electrical equipment work	50	14	8.90	<0.01	S3
what is black hole in astronomy*	-	75	-	-	-

- shaded boxes show where girls' interests are significantly higher than boys'

Comparison of S3 and S5/S6 girls' interests in Physics topics

topics suggested	S3 Boys N=69	S5/S6 Boys N=68	χ^2	significance %	favoured
how musical instrument works	26	22	0.30	ns	-
why we usually have a rainbow after the rain	22	32	1.74	ns	-
is it safe to use nuclear power for producing electricity	52	46	0.49	ns	-
how can we increase the power of the car engine	50	56	0.50	ns	-
how does the telescope work	38	22	4.17	<0.05	S3
which atmospheric factors influence the weather on the planet	33	26	0.81	ns	-
why use of X-rays can be harmful for the human body	39	26	2.64	ns	-
why do we have earthquakes	60	40	5.48	<0.05	S3
how to construct the simple device to measure the level of radiation	42	29	2.53	ns	-
how to solve the world food problem	25	29	0.28	ns	-
how can I earn money by applying my knowledge	86	75	2.65	ns	-
how to understand the way electrical equipment work	63	38	8.56	<0.01	S3
what is black hole in astronomy*	-	69	-	-	-

- shaded boxes show where girls' interests are significantly higher than boys'

Comparison of boys' and girls' patterns of interests in Physics topics
(data taken from the Graphs 10-1, 10-2)

	P6/P7 %	**S2** %	**S3** %	**S4** %	**S5/S6** %	χ^2	**df**	**significance** %	**favoured**
Why do we have earthquakes?									
Girls	71	52	83	35	57				
Boys	66	53	60	53	40	5.12	4	ns	-
How to understand the way electrical equipment work?									
Girls	50	36	50	18	14				
Boys	68	67	63	46	38	8.94	4	ns	-
Why use of X-rays can be harmful for the human body?									
Girls	50	57	60	42	54				
Boys	47	55	39	28	26	5.43	4	ns	-
Is it safe to use nuclear power for producing electricity?									
Girls	26	25	36	18	36				
Boys	51	48	52	33	46	2.82	4		-
How can I earn money by applying my knowledge?									
Girls	-	58	62	35	43				
Boys	-	70	80	84	75	22.54	3	<0.01	Boys

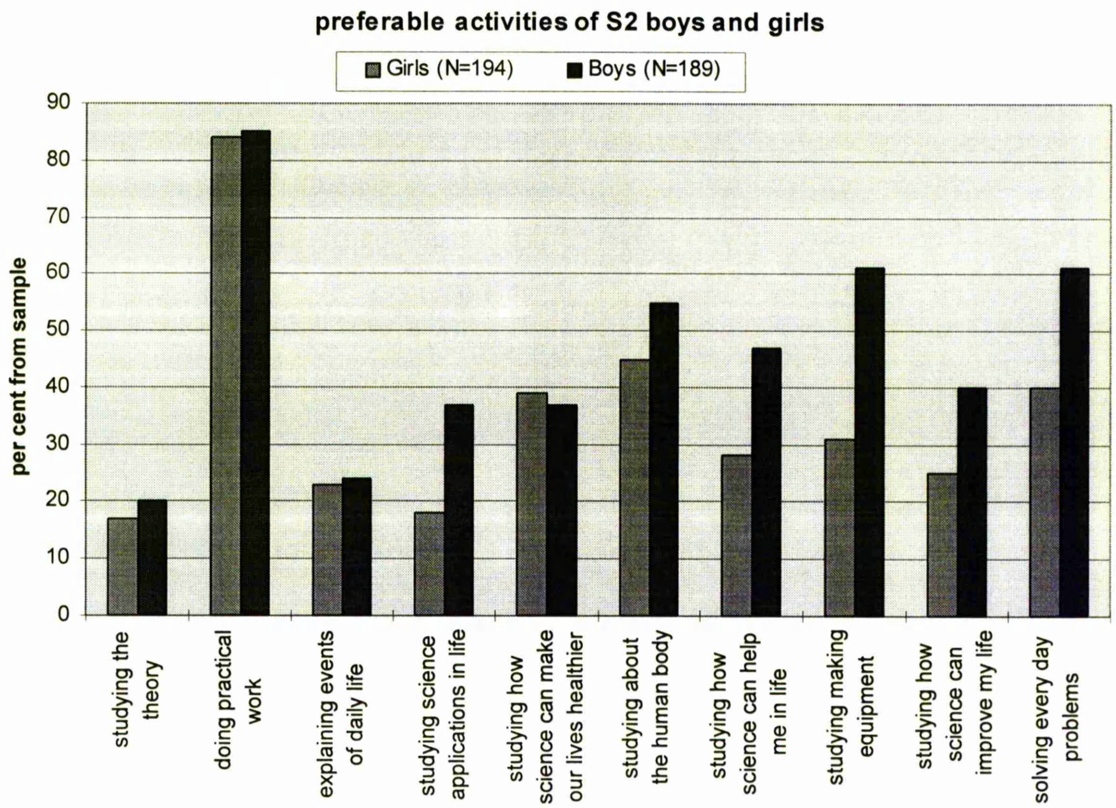
Appendix F

Preferable activities in Science/Physics lessons

S2 pupils

N.	What do you enjoy most in your science lessons?	Girls, N=194 %	Boys, N=189 %	χ^2	significance %	favoured
1	studying the theory	17	20	0.57	ns	-
2	doing practical work	84	85	0.07	ns	-
3	explaining events of daily life	23	24	0.05	ns	-
4	studying science applications in life	18	37	17.38	<0.01	Boys
5	studying how science can make our lives healthier	39	37	0.16	ns	-
6	studying about the human body	45	55	3.83	ns	-
7	studying how science can help me in life	28	47	14.77	<0.01	Boys
8	studying making equipment	31	61	34.71	<0.01	Boys
9	studying how science can improve my life	25	40	9.84	<0.01	Boys
10	solving every day problems	40	61	16.89	<0.01	Boys

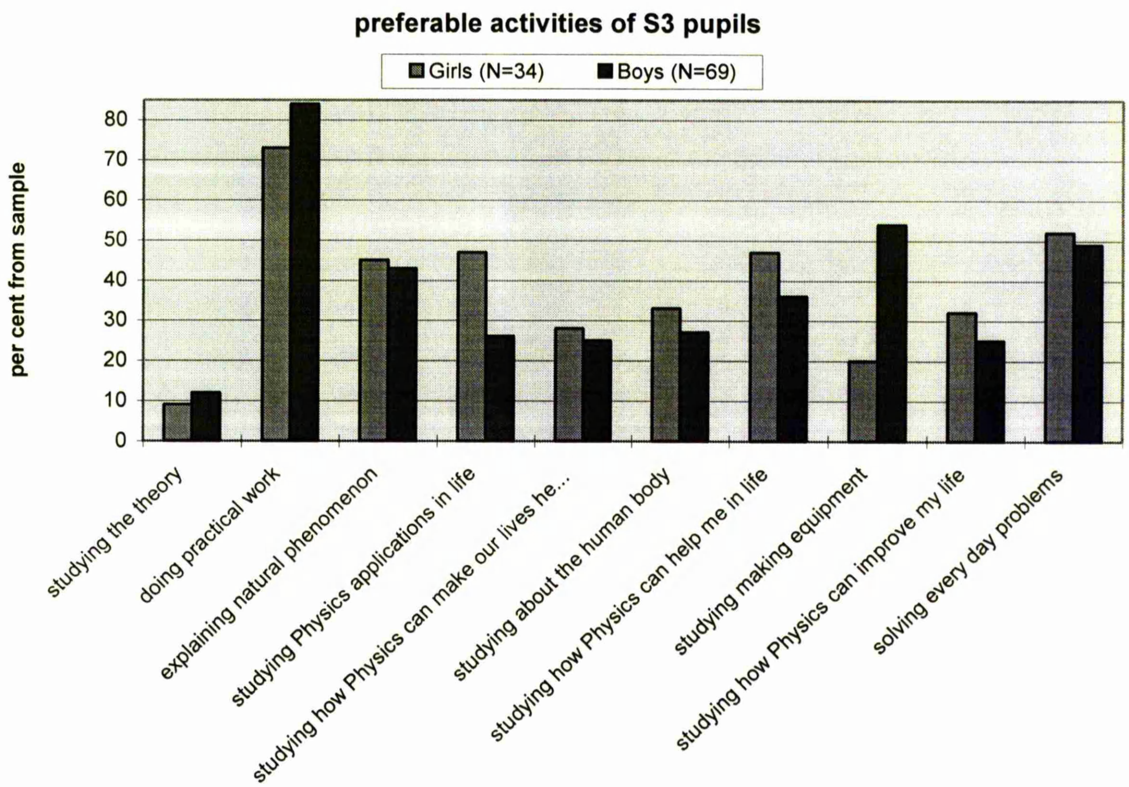
- df=1
- "ns" means "not significant", level of significance is higher than 5%.



S3 pupils

No.	What do you enjoy most in your science lessons?	Girls, N=34 %	Boys, N=69 %	χ^2	significance %	favoured
1	studying the theory	9	12	0.21	ns	-
2	doing practical work	73	84	1.75	ns	-
3	explaining natural phenomenon	45	43	0.04	ns	-
4	studying Physics applications in life	47	26	4.55	<0.05	Girls
5	studying how Physics can make our lives healthier	28	25	0.11	ns	-
6	studying about the human body	33	27	0.40	ns	-
7	studying how Physics can help me in life	47	36	1.15	ns	-
8	studying making equipment	20	54	10.76	<0.01	Boys
9	studying how Physics can improve my life	32	25	0.56	ns	-
10	solving every day problems	52	49	0.08	ns	-

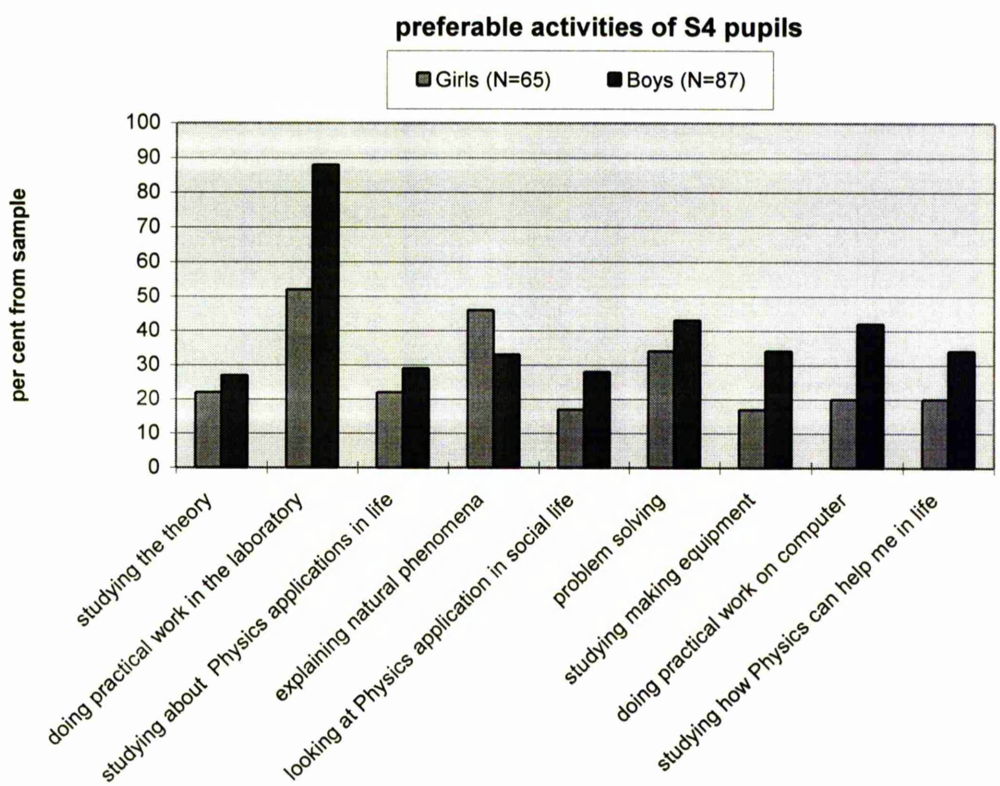
- df=1
- "ns" means "not significant", level of significance is higher than 5%.



S4 pupils

	What do you enjoy most in your science lessons?	**Girls, N=65 %**	**Boys, N=87 %**	χ^2	**significance %**	**favoured**
1	studying the theory	22	27	0.47	ns	-
2	doing practical work in the laboratory	52	88	22.43	<0.01	Boys
3	studying about Physics applications in life	22	29	0.90	ns	-
4	explaining natural phenomena	46	33	2.51	ns	-
5	looking at Physics application in social life	17	28	2.41	ns	-
6	problem solving	34	43	1.20	ns	-
7	studying making equipment	17	34	5.27	<0.05	Boys
8	doing practical work on computer	20	42	7.85	<0.01	Boys
9	studying how Physics can help me in life	20	34	3.46	ns	-

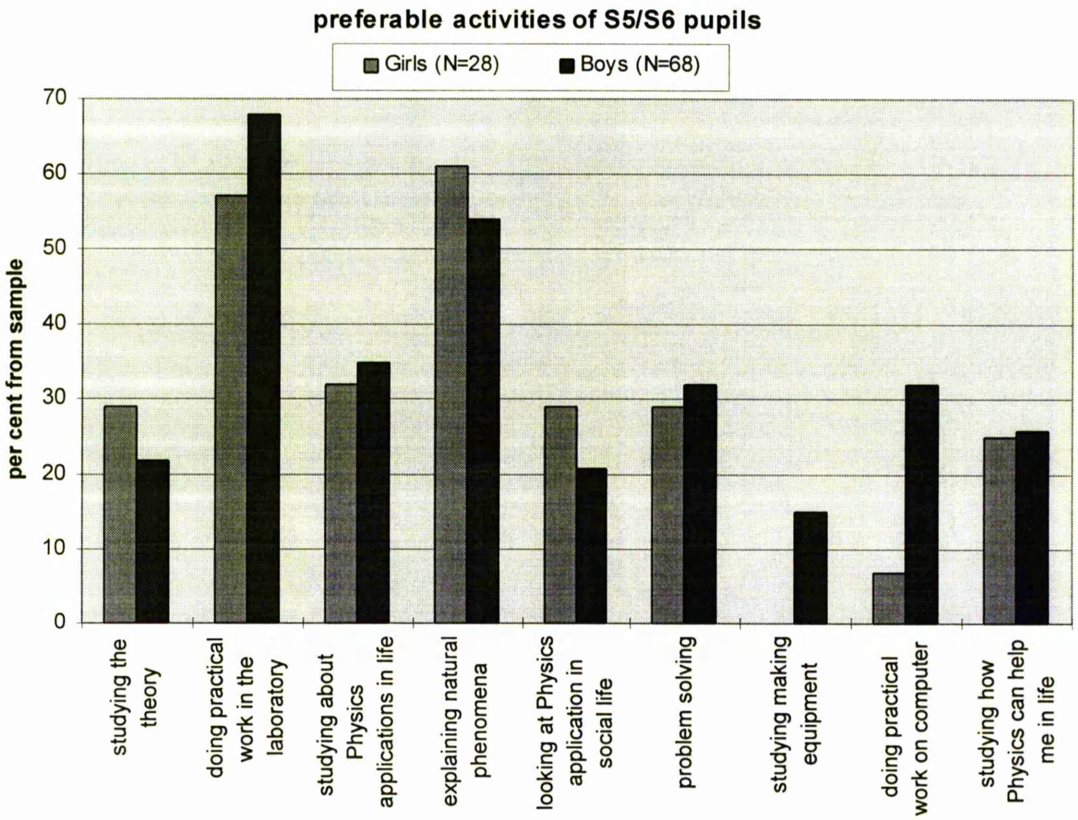
- df=1
- "ns" means "not significant", level of significance is higher than 5%.



S5/S6 pupils

No.	What do you enjoy most in your science lessons?	Girls, N=28 %	Boys, N=68 %	χ^2	significance %	favoured
1	studying the theory	29	22	0.53	ns	-
2	doing practical work in the laboratory	57	68	1.05	ns	-
3	studying about Physics applications in life	32	35	0.08	ns	-
4	explaining natural phenomena	61	54	0.40	ns	-
5	looking at Physics application in social life	29	21	0.71	ns	-
6	problem solving	29	32	0.08	ns	-
7	studying making equipment	0	15	-	-	Boys
8	doing practical work on computer	7	32	-	-	Boys
9	studying how Physics can help me in life	25	26	0.01	ns	-

- df=1
- "ns" means "not significant", level of significance is higher than 5%.



S2 and S3 girls

No.	What do you enjoy most in your science lessons?	S2 Girls, N=194 %	S3 Girls, N=34 %	χ^2	significance %	favoured
1	studying the theory	17	9	1.39	ns	-
2	doing practical work	84	73	2.41	ns	-
3	explaining events of daily life/natural phenomenon	23	45	7.23	ns	-
4	studying science /Physics applications in life	18	47	14.03	<0.01	S3
5	studying how science/Physics can make our lives healthier	39	28	1.50	ns	-
6	studying about the human body	45	33	1.70	ns	-
7	studying how science/Physics can help me in life	28	47	4.90	<0.05	S3
8	studying making equipment	31	20	1.69	ns	-
9	studying how science/Physics can improve my life	25	32	0.74	ns	-
10	solving every day problems	40	52	1.71	ns	-

* shaded boxes show where girls are significantly higher than boys

S2 and S3 boys

No.	What do you enjoy most in your science lessons?	S2 Boys N=189 %	S3 Boys, N=69 %	χ^2	significance %	favoured
1	studying the theory	20	12	2.21	ns	-
2	doing practical work	85	84	0.04	ns	-
3	explaining events of daily life/natural phenomenon	24	43	8.85	<0.01	S3
4	studying science /Physics applications in life	37	26	2.72	ns	-
5	studying how science/Physics can make our lives healthier	37	25	3.25	ns	-
6	studying about the human body	55	27	15.89	<0.01	S2
7	studying how science/Physics can help me in life	47	36	2.48	ns	-
8	studying making equipment	61	54	1.03	ns	-
9	studying how science/Physics can improve my life	40	25	4.94	<0.05	S2
10	solving every day problems	61	49		ns	-

* shaded boxes show where boys are significantly higher than girls

S3 and S4 Girls

No.	What do you enjoy most in your science lessons?	S3 Girls, N=34 %	S4 Girls N=65 %	χ^2	significance %	favoured
1	studying the theory	9	22	1.20	ns	-
2	doing practical work	73	52	4.80	<0.05	S3
3	explaining natural phenomenon	45	46	0.09	ns	-
4	studying Physics applications in life	47	22	6.57	<0.01	S3
7	studying how Physics can help me in life	47	20	7.86	<0.01	S3
8	studying making equipment	20	17	0.14	ns	-
10	solving every day problems	52	34	3.01	ns	-

* shaded boxes show where girls are significantly higher than boys

S3 and S4 Boys

	What do you enjoy most in your science lessons?	S3 Boys, N=69 %	S4 Boys N=87 %	χ^2	significance %	favoured
1	studying the theory	12	27	5.14	<0.05	S4
2	doing practical work	84	88	0.49	ns	-
3	explaining natural phenomenon	43	33	1.55	ns	-
4	studying Physics applications in life	26	29	0.17	ns	-
7	studying how Physics can help me in life	36	34	0.07	ns	-
8	studying making equipment	54	34	5.93	<0.05	S3
10	solving every day problems	49	43	0.53	ns	-

* shaded boxes show where boys are significantly higher than girls

S4 and S5 Girls

No.	What do you enjoy most in your science lessons?	S4 Girls, N=65 %	S5 Girls N=28 %	χ^2	significance %	favoured
1	studying the theory	22	29	0.53	ns	-
2	doing practical work in the laboratory	52	57	0.20	ns	-
3	studying about Physics applications in life	22	32	1.04	ns	-
4	explaining natural phenomena	46	61	1.76	ns	-
5	looking at Physics application in social life	17	29	1.72	ns	-
6	problem solving	34	29	0.22	ns	-
7	studying making equipment	17	0	-	-	-
8	doing practical work on computer	20	7	1.00	ns	-
9	studying how Physics can help me in life	20	25	0.24	ns	-

* shaded boxes show where girls are significantly higher than boys

S4 and S5 Boys

No.	What do you enjoy most in your science lessons?	S4 Boys, N=87 %	S5 Boys N=68 %	χ^2	significance %	favoured
1	studying the theory	27	22	0.49	ns	-
2	doing practical work in the laboratory	88	68	8.59	<0.01	S4
3	studying about Physics applications in life	29	35	0.60	ns	-
4	explaining natural phenomena	33	54	6.50	<0.05	S5
5	looking at Physics application in social life	28	21	0.95	ns	-
6	problem solving	43	32	1.86	ns	-
7	studying making equipment	34	15	6.94	<0.01	S4
8	doing practical work on computer	42	32	1.55	ns	-
9	studying how Physics can help me in life	34	26	1.10	ns	-

* shaded boxes show where boys are significantly higher than girls

Preferable activities of girls

No.	What do you enjoy most in your science lessons?	S2 Girls N=194 %	S3 Girls N=34 %	S4 Girls N=65 %	S5/S6 Girls N=28	χ^2	significance %	df
1	studying the theory	17	9	22	29	4.94	ns	3
2	doing practical work	84	73	52	57	30.66	<0.01	3
3	explaining events of daily life/natural phenomenon	23	45	46	61	25.75	<0.01	3
4	studying science/Physics applications in life	18	47	22	32	15.07	<0.01	3
5	studying how science/Physics can make our lives healthier	39	28	-	-	1.50	ns	1
6	studying about the human body	45	33	-	-	1.70	ns	1
7	studying how science/ Physics can help me in life	28	47	20	25	8.25	<0.05	3
8	studying making equipment	31	20	17	0	-	-	3
9	studying how science/Physics can improve my life	25	32	-	-	0.74	ns	1
10	solving every day problems	40	52	34	29	4.35	ns	3
11	doing practical work on computer	-	-	20	7	-	-	1

* shaded boxes show where girls are significantly higher than boys

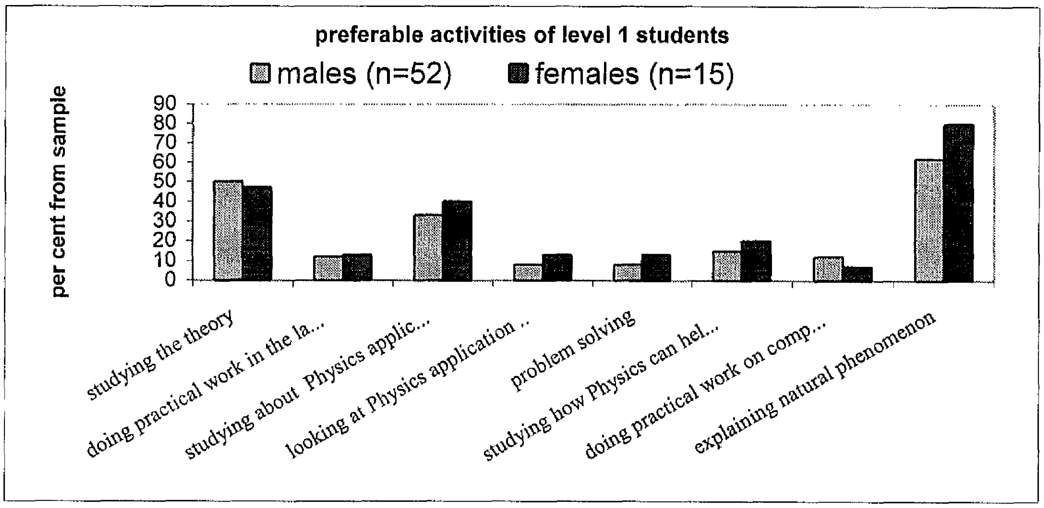
Preferable activities of boys

	What do you enjoy most in your science lessons?	S2 Boys N=189 %	S3 Boys N=69 %	S4 Boys N=87 %	S5/S6 Boys N=68	χ^2	significance %	df
1	studying the theory	20	12	27	22	5.21	ns	3
2	doing practical work	85	84	88	68	12.46	<0.01	3
3	explaining events of daily life/natural phenomenon	24	43	33	54	23.06	<0.01	3
4	studying science/Physics applications in life	37	26	29	35	3.55	ns	3
5	studying how science/Physics can make our lives healthier	37	25	-	-	3.25	ns	1
6	studying about the human body	55	27	-	-	15.89	<0.01	1
7	studying how science/ Physics can help me in life	47	36	34	26	10.98	<0.05	3
8	studying making equipment	61	54	34	15	49.42	<0.01	3
9	studying how science/Physics can improve my life	40	25	-	-	4.94	<0.05	1
10	solving every day problems	61	49	43	32	19.44	<0.01	3
11	doing practical work on computer	-		42	32	2.73	ns	1

- shaded boxes show where boys are significantly higher than girls

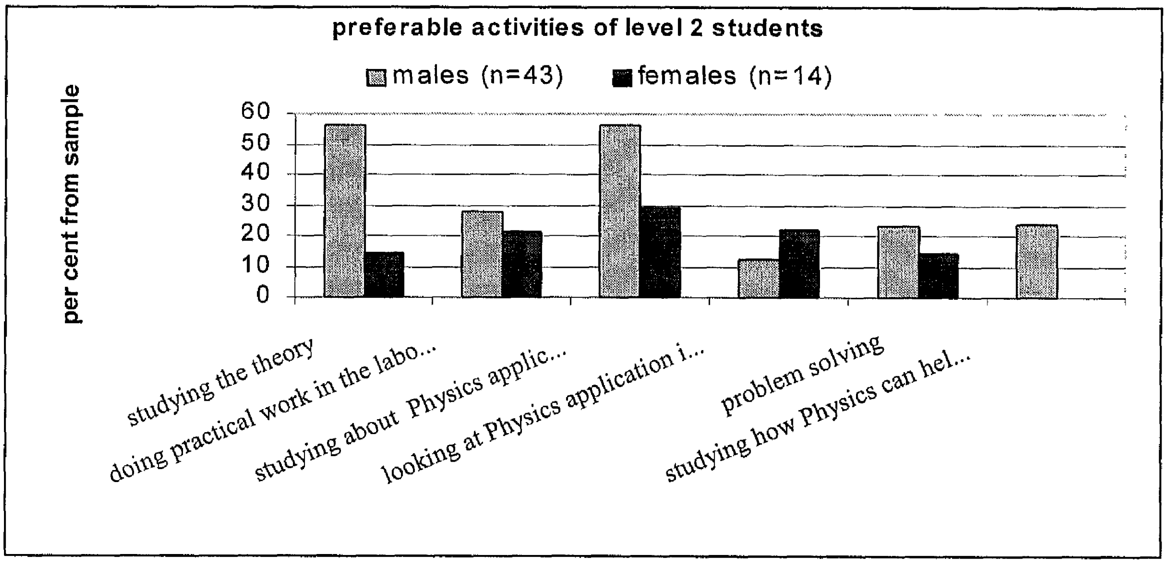
Level 1 (98/99) students

	What do you enjoy most in your science lessons?	Males N=52, %	Females N=15, %	χ^2	significance %	favoured
1	studying the theory	50	47	0.04	ns	-
2	doing practical work in the laboratory	12	13	-	-	-
3	studying about Physics applications in life	33	40	0.25	ns	-
4	looking at Physics application in social life	8	13	-	-	-
5	problem solving	8	13	-	-	--
6	studying how Physics can help me in life	15	20	0.22	ns	-
7	doing practical work on computer	12	7	-	-	-
8	explaining natural phenomenon	62	80	1.68	ns	-



Level 2 (98/99) students

	What do you enjoy most in your science lessons?	Males n=43, %	Females n=14, %	χ^2	significance %	favoured
1	studying the theory	56	14	7.5	ns	-
2	doing practical work in the laboratory	28	21	0.27	ns	-
3	studying about Physics applications in life	56	29	3.08	ns	-
4	looking at Physics application in social life	12	22	0.85	ns	-
5	problem solving	23	14	-	-	-
6	studying how Physics can help me in life	24	0	-	-	-
7	doing practical work on computer	28	7	-	-	-
8	explaining natural phenomenon	84	67	1.90	ns	-



Appendix G

Primary P6/P7 and secondary pupils

P6/P7 pupils:

I would like to learn more science in secondary school, because:

	Girls, % (N=65)	**Boys, % (N=66)**	χ^2	**significance, %**	**df**
I like it	10.8	18.2	1.29	ns	1
It is interesting	26.2	19.7	0.92	ns	1
I enjoy it	12.3	13.6	0.12	ns	1
It is important subject	9.2	1.5	1.81	ns	1
I enjoy doing experiments	12.3	22.7	2.74	ns	1
Science is fun	12.3	12.1	0.01	ns	1
It is useful in life	1.6	9.1	1.61	ns	1
I need it for a career	1.6	3.0	0.08	ns	1
I want to learn more	30.8	21.2	1.70		-
I am good at it	1.5	0	-	ns	1

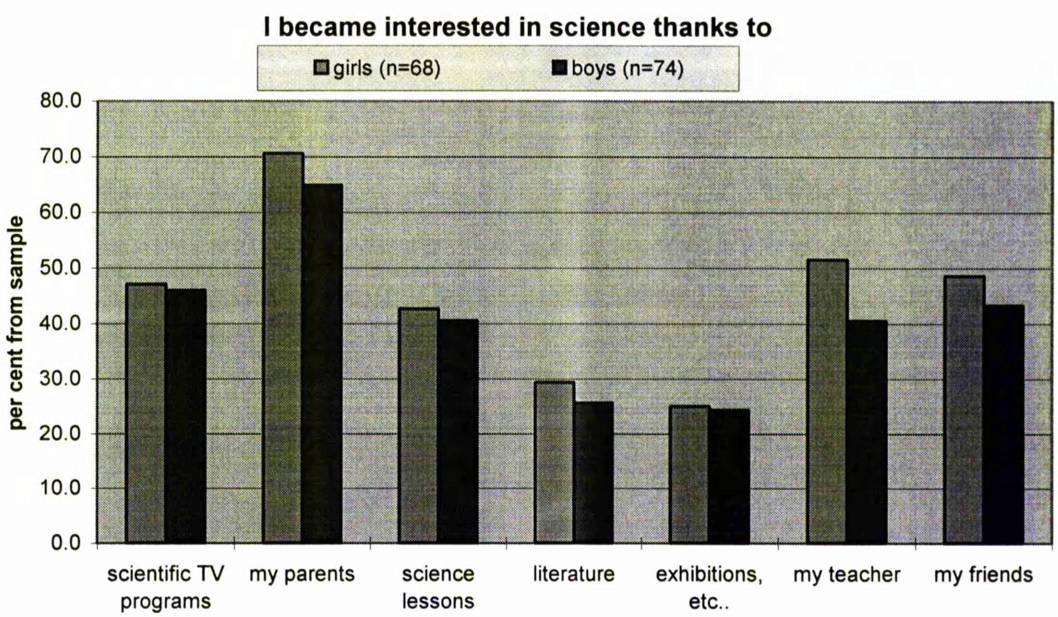
Note: "ns" means "not significant", level of significance higher than 5%

P6/P7 pupils

I became interested in science thanks to…

	Girls, % (N=68)	Boys, % (N=74)	χ^2	significance, %	df	favoured
scientific TV programs	47.1	45.9	0.02	ns	1	-
my parents	70.6	64.9	0.53	ns	1	-
science lessons	42.6	40.5	0.07	ns	1	-
literature	29.4	25.7	0.24	ns	1	-
exhibitions, demonstrations, festivals, etc..	25.0	24.3	0.01	ns	1	-
my teacher	51.5	40.5	1.73	ns	1	-
my friends	48.5	43.2	0.4	ns	1	-

Note: "ns" means "not significant", significance is higher than 5%.

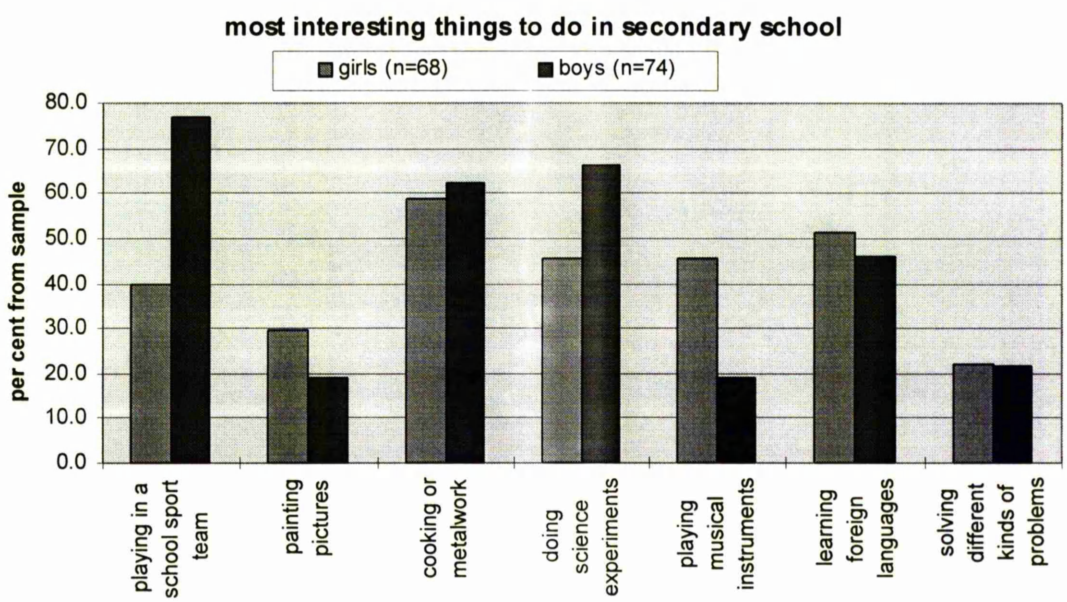


P6/P7 pupils

What are your most interesting to do in secondary school?

	Girls, % (N=68)	Boys, % (N=74)	χ^2	significance, %	df	preference
playing in a school sport team	39.7	77.0	20.40	<0.01	1	Boys
painting pictures	29.4	18.9	2.15	ns	1	
cooking or metalwork	58.8	62.2	0.17	ns	1	
doing science experiments	45.6	66.2	6.11	<0.05	1	Boys
playing musical instruments	45.6	18.9	11.67	<0.01	1	Girls
learning foreign languages	51.5	45.9	0.45	ns	1	
solving different kinds of problems	22.1	21.6	0.01	ns	1	

Note: "ns" means "not significant"



S2: Would you like to study Physics for a Standard Grade?

School	Girls, %				Boys, %			
	N.	Yes	No	χ^2	N.	Yes	No	χ^2
School 1	49	45	49		41	56	36	
School 2	83	31	64		79	50	47	
School 3	62	24	71	6.01*	69	65	33	3.12

Note: chi-square equal 6.01 is significant at 5% level of significance when df=2.

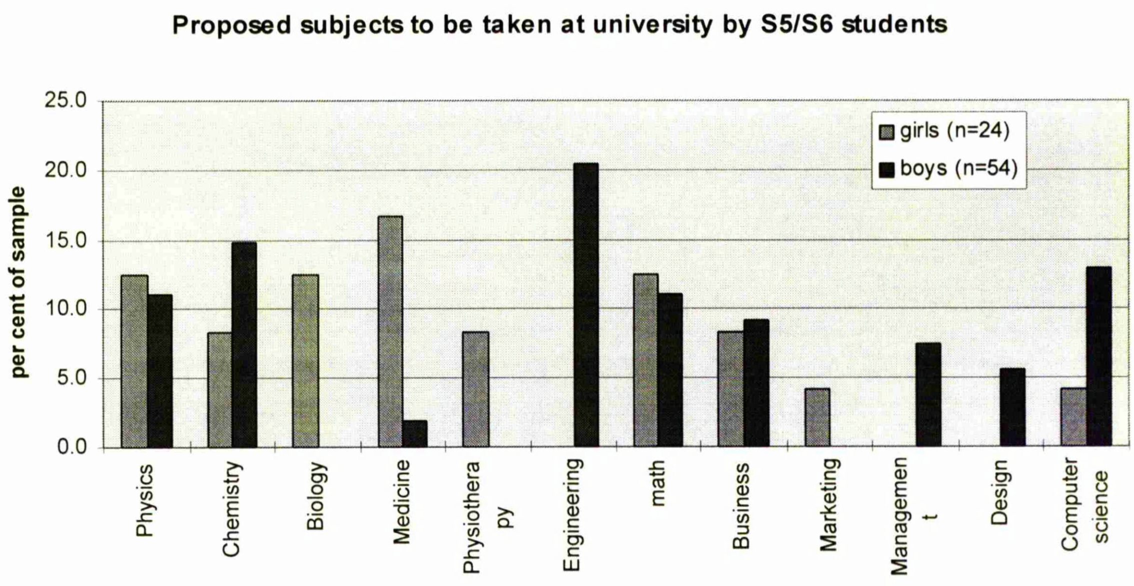
Appendix H

Higher Grade Physics students

S5/S6 pupils: subjects to study at university level

	Girls, % (N=24)	Boys, % (N=54)	χ^2
Physics	13	11	-
Chemistry	8	15	-
Biology	13	0	-
Medicine	17	2	-
Physiotherapy	8	0	-
Engineering	0	21	-
Mathematics	13	11	-
Business	8	9	-
Marketing	4	0	-
Management	0	8	-
Design	0	6	-
Computer Science	4	13	-

It was impossible to evaluate the differences between boys' and girls' choices using a chi-square. The graph below provides the distribution of choices separately for girls and boys.



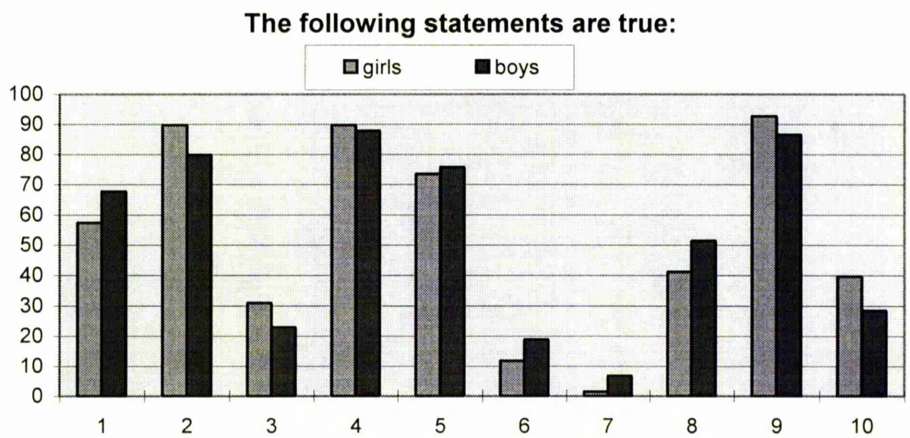
Appendix I

Being a Physicist is likely to be…

P6/P7 pupils

	As a general rule, each statement below is true	Girls, N=68 %	Boys, N=74 %	χ^2	significance %	df
1	all scientist are very intelligent people	57	68	1.84	ns	1
2	being a scientist is very interesting	90	80	2.75	ns	1
3	scientists usually wearing spectacles	31	23	1.56	ns	1
4	scientists work to make discoveries	90	88	0.15	ns	1
5	being a scientist is hard	74	76	0.08	ns	1
6	scientists usually are rich people	12	19	1.32	ns	1
7	females don't like being scientists	1	7	-		1
8	being a scientist is dangerous for the health	41	51	1.43	ns	1
9	scientists should wear goggles while working	93	86	1.83	ns	1
10	being a scientists is not popular our days	40	28	2.28	ns	1

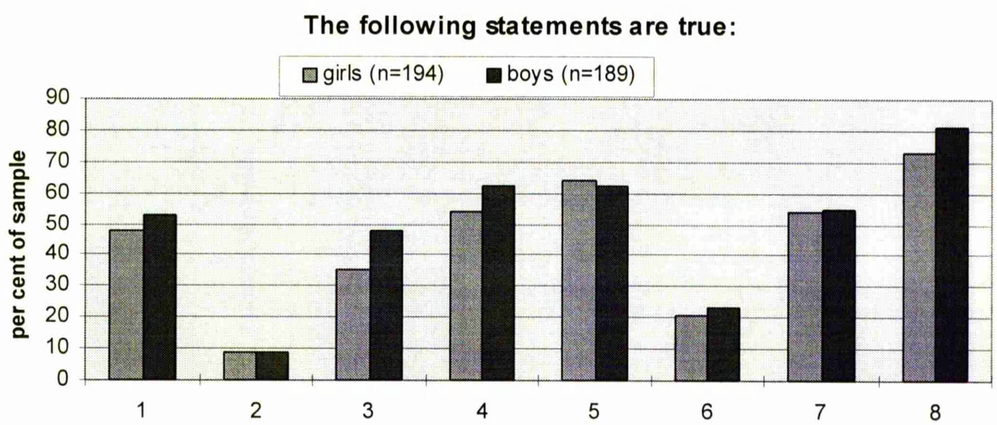
Note: "ns" means "not significant", level of significance is higher 5%



S2 pupils

	As a general rule, each statement below is true	Girls, N=194 %	Boys, N=189 %	χ^2	significance %	preference
1	all Physicist are very intelligent people	48	53	0.96	ns	
2	being a Physicist means finding a job easy	9	9	0	ns	
3	Physicists are involved in the process of describing nature and its laws	35	48	6.67	<0.05	Boys
4	Physicists have a very high salary	54	62	2.52	ns	
5	Physicists work to make our lives safer and more comfortable	64	62	0.17	ns	
6	Physicists are strongly involved in the study of human body	21	23	0.22	ns	
7	Physicists are very enthusiastic people and often work for the sake of personal interest	54	55	0.04	ns	
8	Physicists have excellent career opportunities	73	81	3.46	ns	

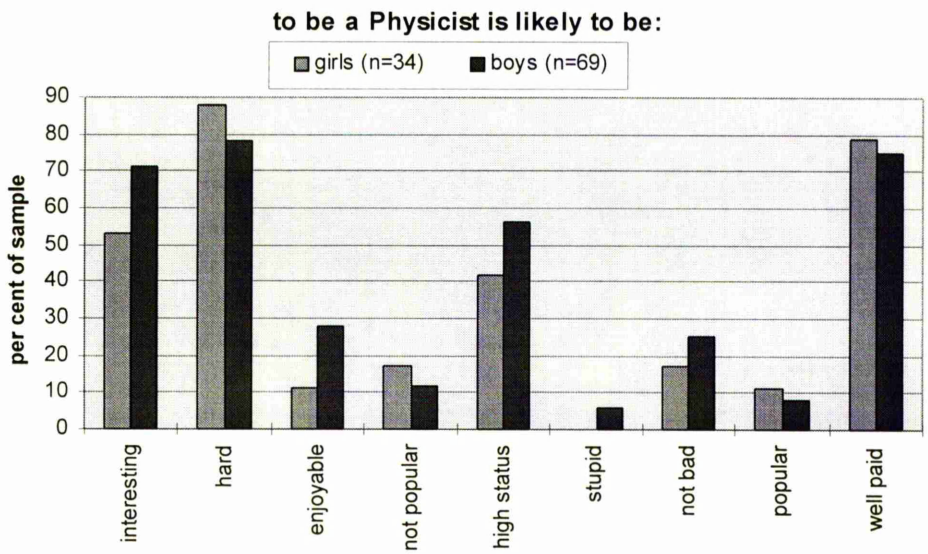
Note: df=1 for every case
"ns" means "not significant", level of significance is higher 5%



S3 pupils

	To be a Physicist is likely to be	Girls, N=34 %	Boys, N=69 %	χ^2	significance %	df
1	interesting	53	71	3.25	ns	1
2	hard	88	78	1.50	ns	1
3	enjoyable	11	28	3.79	ns	1
4	not popular	17	12	0.48	ns	1
5	high status	42	56	1.79	ns	1
6	stupid	0	6	-	ns	1
7	not bad	17	25	0.84	ns	1
8	popular	11	8	0.25	ns	1
9	well paid	79	75	0.20	ns	1

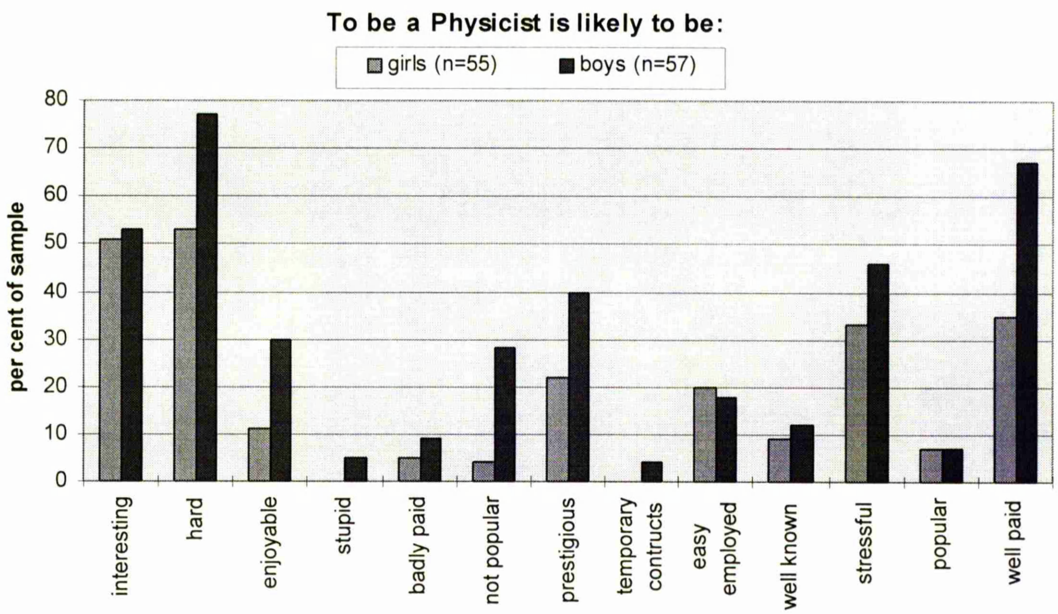
Note: "ns" means "not significant", level of significance is higher 5%



S4 pupils

	To be a Physicist is likely to be	Girls, N=55 %	Boys, N=57 %	χ^2	significance %	preference
1	interesting	51	53	0.05	ns	
2	hard	53	77	7.12	<0.05	Boys
3	enjoyable	11	30	6.16	<0.05	Boys
4	stupid	0	5	-	ns	
5	badly paid	5	9	0.38	ns	
6	not popular	4	28	6.80	<0.05	Boys
7	prestigious	22	40	4.23	ns	
8	always on temporary contracts	0	4	-		
9	easy employed	20	18	0.07	ns	
10	well known	9	12	0.27	ns	
11	stressful	33	46	1.98	ns	
12	popular	7	7	-	ns	
13	well paid	35	67	11.47	<0.01	Boys

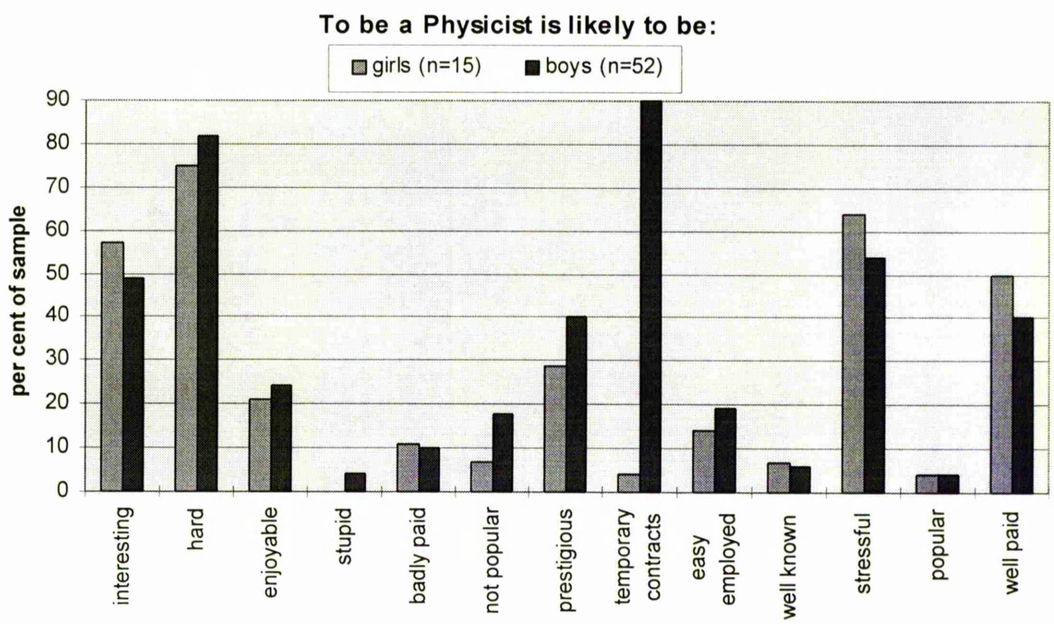
Note: df=1 for every case
"ns" means "not significant", level of significance is higher 5%



S5/S6 pupils

	To be a Physicist is likely to be:	Girls, N=28 %	Boys, N=68 %	χ^2	significance %	df
1	interesting	57	49	0.30	ns	1
2	hard	75	82	0.36	ns	1
3	enjoyable	21	24	0.06	ns	1
4	stupid	0	4	-		
5	badly paid	11	10	-		
6	not popular	7	18	-		
7	prestigious	29	40	0.60	ns	1
8	always on temporary contracts	4	90	-		
9	easy employed	14	19	0.20	ns	1
10	well known	7	6	-		
11	stressful	64	54	0.47	ns	1
12	popular	4	4	-		
13	well paid	50	40	0.48	ns	1

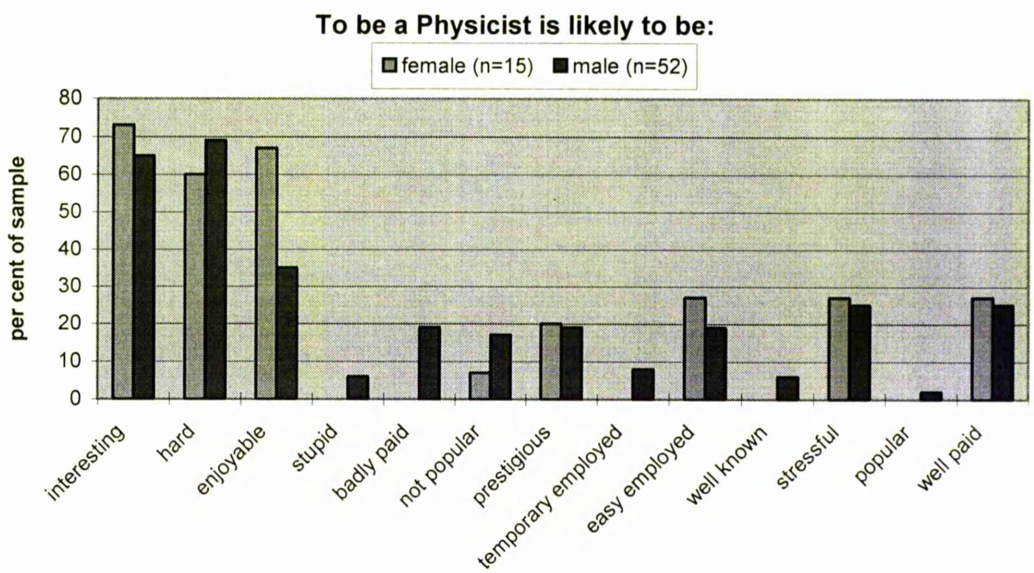
Note: "ns" means "not significant", level of significance is higher 5%



Level 1 (98/99) Physics students

	To be a Physicist is likely to be	Female, N=15 %	Male, N=52 %	χ^2	significance %	preference
1	interesting	73	65	0.34	ns	-
2	hard	60	69	0.43	ns	-
3	enjoyable	67	35	4.89	<0.05	Female
4	stupid	0	6	-	-	-
5	badly paid	0	19	-	-	-
6	not popular	7	17	-	-	-
7	prestigious	20	19	0.01	ns	-
8	temporary employed	0	8	-	-	-
9	easy employed	27	19	0.45	ns	-
10	well known	0	6	-	-	-
11	stressful	27	25	0.03	ns	-
12	popular	0	2	-	-	-
13	well paid	27	25	0.03	ns	-

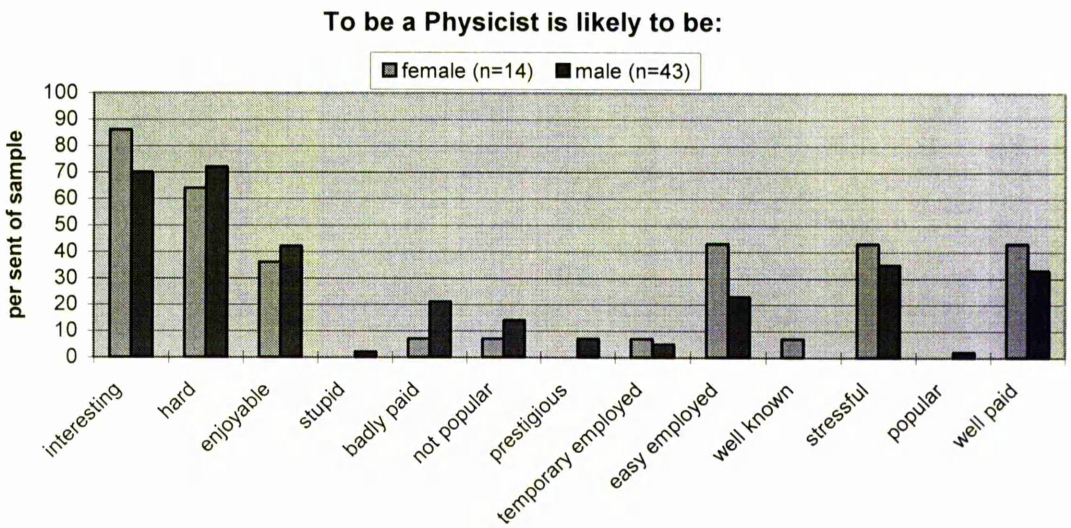
Note: df=1 for every case
"ns" means "not significant", level of significance is higher 5%



Level 2 (98/99) Physics students

	To be a Physicist is likely to be	Girls, N=14 %	Boys, N=43 %	χ^2	significance %	df
1	interesting	86	70	1.40	ns	1
2	hard	64	72	0.32	ns	1
3	enjoyable	36	42	0.16	ns	1
4	stupid	0	2	-	-	
5	badly paid	7	21	-	-	
6	not popular	7	14	-	-	
7	prestigious	0	7	-	-	
8	temporary employed	7	5	-	-	
9	easy employed	43	23	2.10	ns	1
10	well known	7	0	-	-	
11	stressful	43	35	0.29	ns	1
12	popular	0	2	-	-	
13	well paid	43	33	0.46	ns	1

Note: "ns" means "not significant", level of significance is higher 5%



S3 and S4 girls

	To be a Physicist is likely to be	Girls, N=34 %	Girls, N=55 %	χ^2	significance %	preference
1	interesting	53	51	0.03	ns	-
2	hard	88	53	11.53	<0.01	S3
3	enjoyable	11	11	0	-	-
4	not popular	17	4	-	-	-
5	high status	42	22	4.03	<0.05	S3
6	stupid	0	0	-	-	-
7	popular	11	7	-	-	-
8	well paid	79	35	16.29	<0.01	S3

S3 and S4 boys

	To be a Physicist is likely to be	Boys, N=69 %	Boys, N=57 %	χ^2	significance %	preference
1	interesting	71	53	4.33	<0.05	S3
2	hard	78	77	0.02	ns	-
3	enjoyable	28	30	0.06	ns	-
4	not popular	12	28	5.14	<0.05	S4
5	high status	56	40	3.20	ns	-
6	stupid	6	5	-	-	-
7	popular	8	7	-	-	-
8	well paid	75	67	0.98	ns	-

Note: df=1 for every case
"ns" means "not significant", level of significance is higher 5%

S4 and S5/S6 Girls

	To be a Physicist is likely to be	**S4 Girls, N=55 %**	**S5/S6 Girls, N=15 %**	χ^2	significance	preference
1	interesting	51	57	0.17	ns	-
2	hard	53	75	2.34	ns	-
3	enjoyable	11	21	1.03	ns	-
4	stupid	0	0	-	-	-
5	badly paid	5	11	-	-	-
6	not popular	4	7	-	-	-
7	prestigious	22	29	0.32	ns	-
8	always on temporary contracts	0	4	-	-	-
9	easy employed	20	14	0.07	ns	-
10	well known	9	7	-	-	-
11	stressful	33	64	4.73	<0.05	S5/S6
12	popular	7	4	-	-	-
13	well paid	35	50	1.12	ns	-

S4 and S5/S6 Boys

	To be a Physicist is likely to be	**S4 Boys, N=57 %**	**S5/S6 Boys, N=52 %**	χ^2	**significance**	preference
1	interesting	53	49	0.18	ns	-
2	hard	77	82	0.42	ns	-
3	enjoyable	30	24	0.50	ns	-
4	stupid	5	4	-		-
5	badly paid	9	10	0.12	ns	-
6	not popular	28	18	1.53	ns	-
7	prestigious	40	40	0		
8	always on temporary contracts	4	90	60.25	<0.00	S5/S6
9	easy employed	18	19	0.02	ns	-
10	well known	12	6	1.18	ns	-
11	stressful	46	54	0.70	ns	-
12	popular	7	4	-	-	-
13	well paid	67	40	7.98	<0.05	S4

Note: df=1 for every case
"ns" means "not significant", level of significance is higher 5%

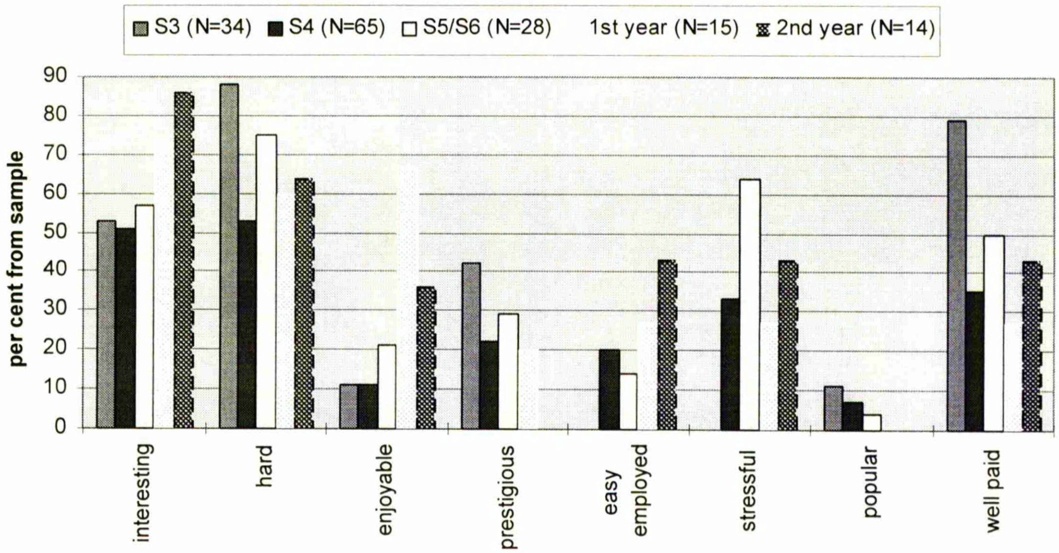
Girls' opinions:

	To be a Physicist is likely to be:	S3 Girls N=34 %	S4 Girls N=65 %	S5/S6 Girls N=28	Level 1 Girls N=15	Level 2 Girls N=14	χ^2	significance	df	preference
1	interesting	53	51	57	73	86	7.55	ns	4	-
2	hard	88	53	75	60	64	13.55	<0.01	4	S3
3	enjoyable	11	11	21	67	36	27.53	<0.01	4	Level 1
4	prestigious	42	22	29	20	0	4.96	ns	3	-
5	easy employed	-	20	14	27	43	4.44	ns	3	-
6	stressful	-	33	64	27	43	9.10	ns	3	-
7	popular	11	7	4	0	0	-	-		-
8	well paid	79	35	50	27	43	20.37	<0.01	4	S3

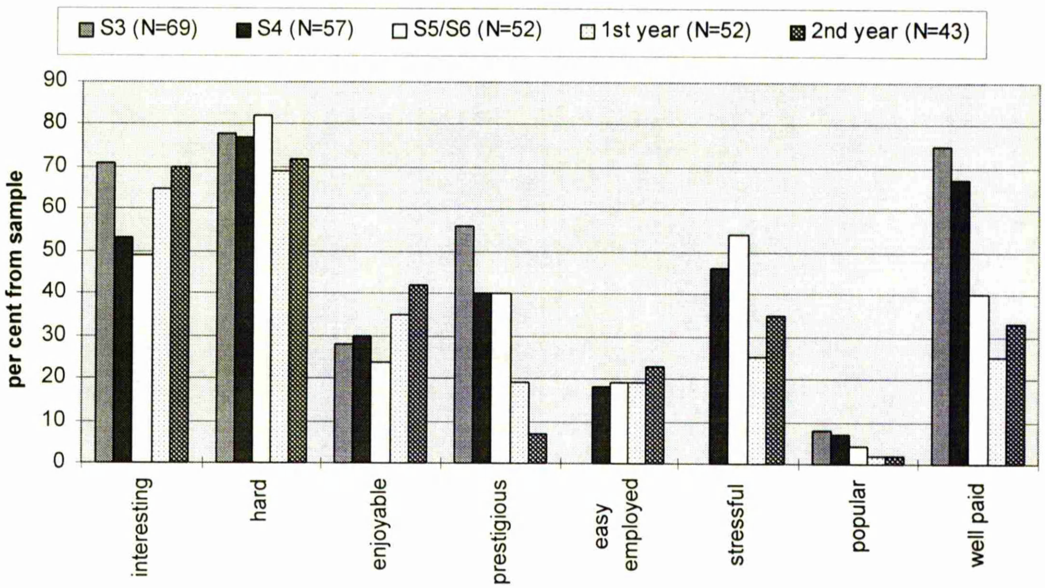
Boys' opinions

	To be a Physicist is likely to be:	S3 Boys N=69 %	S4 Boys N=57 %	S5/S6 Boys N=52	Level 1 Boys N=52	Level 2 Boys N=43	χ^2	significance	df	preference
1	interesting	71	53	49	65	70	9.40	ns	4	-
2	hard	78	77	82	69	72	2.97	ns	4	-
3	enjoyable	28	30	24	35	42	4.31	ns	4	-
4	prestigious	56	40	40	19	7	35.31	<0.01	4	S3
5	easy employed	-	18	19	19	23	0.43	ns	3	-
6	stressful	-	46	54	25	35	10.38	<0.05	3	S5/S6
7	popular	8	7	4	2	2	-	-		-
8	well paid	75	67	40	25	33	43.87	<0.00	4	S3

Girls: To be a Physicist is likely to be:



Boys: To be a Physicist is likely to be:



Appendix J

Educational Statistics

I. Data for entries/passes Standard Grade Physics (Chemistry) and Higher Grade Physics (Chemistry) for Scotland (Scottish Examination Board, Examination Statistics 1994, 95,96)

The number of passes reflects all the candidates who have got grades A – F. But for Higher grade will be allowed only those who have got A, B, C at Standard Grade (for Scotland)

Standard Grade/entries

Entries/N	**1994**			**1995**			**1996**		
	girls	*boys*	*B/G*	*girls*	*boys*	*B/G*	*girls*	*boys*	*B/G*
Chemistry	11313	11876	1.04	12360	12555	1.02	1236 1	12476	1.24
Physics	6630	14367	2.16	7029	14794	2.1	7013	14414	2.1

Higher Grade/entries

Entries/N	**1994**			**1995**			**1996**		
	girls	*boys*	*B/G*	*girls*	*boys*	*B/G*	*girls*	*boys*	*B/G*
Chemistry	5887	6221	1.1	5650	6001	1.1	5840	6040	1.0
Physics	3778	8696	2.3	3717	8235	2.2	3697	8528	2.3

Higher Grade/ passes

Entries/N	**1994**			**1995**			**1996**		
	girls	boys	B/G	girls	boys	B/G	girls	boys	B/G
Chemistry	4251	4481	1.1	3855	4337	1.1	4162	4382	1.1
Physics	2701	5657	2.1	3357	5521	1.6	2755	5638	2.1

Standard grade/ passes

Entries/N	**1994**			**1995**			**1996**		
	girls	boys	B/G	girls	boys	B/G	girls	boys	B/G
Chemistry	11069	11588	1	12146	12307	1	12125	12234	1
Physics	6542	14096	1.2	6949	14587	2.1	6906	14201	2.1

II. Data for entries/passes GCSE in Physics (Chemistry) and GCE in Physics (Chemistry) (Statistics for Education, School Examinations GCSE and GCE, 1991)

GCSE, 15 year old, 1991

Entries/N	**attended**			**gained grades**		
	girls	boys	B/G	girls	boys	B/G
Chemistry	43.75	54.2	1.2	42.92	54.44	1.26
Physics	31.13	68.95	2.2	30.56	67.74	2.21

GCE, 1991

Entries/N	**attended**			**gained grades**		
	girls	boys	B/G	girls	boys	B/G
Chemistry	12.63	18.51	1.46	15.19	10.46	1.5
Physics	6.88	23.47	3.41	18.79	5.58	3.5

** GCE is higher than Higher Grade in Scotland. To complete the GCE a student need to learn two more years after GCSE.

** Higher Educational Statistics for the United Kingdom, 1996/97

Universities	Total number of full-time students
University of Glasgow	18539
University of Strathclyde	18073
University of Edinburgh	15368
Heriot-Watt University	4934

Total number of students studying in	Total UK domicile	From them – Scottish domicile	% of Scottish domicile
Scotland	105.202	81.228	77%
All UK institutions	865.767	88.039	10.2%
Outside Scotland	760.565	6811	1%

Number of full-time and sandwich students doing Physics and Biology in England and in Scotland

	Biology	Physics
England	43219	40366
Scotland	8459	5429
All UK HE	57396	49497

10.96% of all students doing Physics sciences do it in Scottish HE

14.7% of all students doing Biology sciences do it in Scottish HE

source: Students in Higher Education Institutions, 94/95

Full time postgraduate students

	UK			Scotland		
	male	female	M/F	male	female	M/F
Physics	5959	2218	2.7	586	210	2.8
Biology	3090	2759	1.1	488	404	1.2

Appendix K

Results of correlation analyses

Correlation (Kendall's tau_b) – "**Committed students", N=60 (level 1 97/98)**

	Higher Maths.	Higher Physics	Term 1 exams (P1X)	Term 2 exams (P1Y)
Higher Maths.	1	0.509**	0.173	0.426**
Higher Physics		1	0.206	0.138
Term 1 exams (P1X)			1	-0.016
Term 2 exams (P1Y)				1

** Correlation is significant at the 1% level (2-tailed).

Correlation (Kendall's tau_b) – "**Withdrew students", N=27 (level 1 97/98)**

	Higher Maths.	Higher Physics	Term 1 exams (P1X)	Term 2 exams (P1Y)
Higher Maths.	1	0.652**	0.116	0.506**
Higher Physics		1	0.246	0.653**
Term 1 exams (P1X)			1	0.188
Term 2 exams (P1Y)				1

** Correlation is significant at the 1% level (2-tailed).

Correlation (Kendall's tau_b) – **Males, N=88 (level 1 97/98)**

	Higher Maths.	Higher Physics	Term 1 exams (P1X)	Term 2 exams (P1Y)
Higher Maths.	1.000	0.505**	0.097	0.464**
Higher Physics		1.000	0.223*	0.440**
Term 1 exams (P1X)			1.000	0.054
Term 2 exams (P1Y)				1.000

** Correlation is significant at the 1% level (2-tailed).
* Correlation is significant at the 5% level (2-tailed).

Correlation (Kendall's tau_b) – **Females , N=28 (level 1 97/98)**

	Higher Maths.	Higher Physics	Term 1 exams (P1X)	Term 2 exams (P1Y)
Higher Maths.	1	0.631**	0.042	0.687**
Higher Physics		1	0.065	0.407*
Term 1 exams (P1X)			1	-0.065
Term 2 exams (P1Y)				1

** Correlation is significant at the 1% level (2-tailed).
* Correlation is significant at the 5% level (2-tailed).

Correlation (Kendall's tau_b) - **Committed, N=60 (level 1 97/98)**

		Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q13	Q14
Q1	like teacher (s)	1.00	0.23*	0.16	-0.01	-0.02	-0.05	0.74**	0.62**	0.22*	0.11	0.09	0.20	0.20	0.25
Q2	obtain skills (u)		1.00	0.43**	0.29**	0.16	0.05	0.19	0.15	0.10	-0.01	0.18	0.21	0.40**	0.53**
Q3	lectures interesting (u)			1.00	0.36**	0.07	-0.01	0.23*	0.23*	0.00	0.15	0.28**	0.24*	0.51**	0.55
Q4	Labs. Interesting (u)				1.00	0.31**	0.14	0.14	-0.04	0.05	-0.01	0.23*	0.13	0.35**	0.37
Q5	course too mathematical (u)					1.00	0.39**	-0.05	-0.16	-0.01	-0.37**	-0.10	-0.19	0.14	0.07
Q6	course too demanding (u)						1.00	-0.04	-0.08	-0.34**	-0.58**	-0.31**	-0.37**	0.01	-0.01
Q7	like lessons (s)							1.00	0.64**	0.24*	0.12	0.06	0.24*	0.19	0.27
Q8	lessons interesting (s)								1.00	0.15	0.15	0.03	0.26*	0.25	0.19
Q9	Subject easy (s)									1.00	0.33**	0.04	0.08	-0.13	0.11
Q10	Course easy (u)										1.00	0.40**	0.38**	0.10	0.21
Q11	I cope well (u)											1.00	0.48**	0.36**	0.41
Q12	It is "my" subject (u)												1.00	0.33**	0.39
Q13	growing intellectually (u)													1.00	0.50
Q14	I enjoy subject (u)														1.000

** Correlation is significant at the 1% level (2-tailed).
* Correlation is significant at the 5% level (2-tailed).

Correlation (Kendall's tau_b) – **"Withdrew students", N=27 (level 1 97/98)**

		Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q13	Q14
Q1	like teacher (s)	1.000	0.26	0.08	-0.03	0.17	0.10	0.50**	0.40*	0.19	-0.30	0.011	0.04	-0.03	-0.02
Q2	obtain skills (u)		1.00	0.33*	0.44**	-0.03	0.10	0.14	0.12	0.01	-0.01	0.34*	0.14	0.26	0.37*
Q3	lectures interesting (u)			1.00	0.15	0.15	0.38	0.14	0.38*	-0.09	0.27	0.36*	0.40*	0.40*	0.55**
Q4	Labs. Interesting (u)				1.00	0.09	-0.06	0.27	0.12	-0.20	-0.10	0.16	0.11	0.21	0.22
Q5	course too mathematical (u)					1.00	0.57**	0.13	0.25	-0.05	-0.23	-0.14	0.12	-0.18	-0.25
Q6	course too demanding (u)						1.00	0.04	0.24	0.03	-0.14	-0.08	0.18	0.06	0.11
Q7	like lessons (s)							1.00	0.51**	-0.02	0.08	0.02	0.31	0.05	0.13
Q8	lessons interesting (s)								1.00	0.14	-0.05	0.17	0.30	0.27	0.42*
Q9	Subject easy (s)									1.00	0.00	0.01	-0.11	-0.01	0.13
Q10	Course easy (u)										1.00	0.40*	0.13	0.29	0.18
Q11	I cope well (u)											1.000	0.11	0.28	0.36*
Q12	It is "my" subject (u)												1.00	0.32	0.33*
Q13	growing intellectually (u)													1.00	0.52**
Q14	I enjoy subject (u)													0.523	1.00

** Correlation is significant at the 1% level (2-tailed).
* Correlation is significant at the 5% level (2-tailed).

Correlation (Kendall's tau_b) - **Male, N=88 (level 1 97/98)**

		Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q13	Q14
Q1	like teacher (s)	1.00	0.27**	0.24**	-0.01	0.03	-0.13	0.52**	0.46**	0.13	0.13	0.17	0.14	0.19*	0.19*
Q2	obtain skills (u)		1.00	0.30**	0.34**	0.12	0.04	0.19*	0.14	0.04	-0.01	0.21*	0.23*	0.26**	0.38**
Q3	lectures interesting (u)			1.00	0.17	0.03	0.03	0.33**	0.38**	0.04	0.25**	0.36**	0.30**	0.46**	0.53**
Q4	Labs. Interesting (u)				1.00	0.16	-0.03	0.14	-0.07	-0.06	0.04	0.21*	0.15	0.21	0.24**
Q5	course too mathematical (u)					1.00	0.30**	-0.10	-0.10	-0.11	-0.31**	-0.11	-0.11	0.00	-0.07
Q6	course too demanding (u)						1.00	-0.11	-0.07	-0.27**	-0.50**	-0.34**	-0.31**	-0.01	-0.03
Q7	like lessons (s)							1.00	0.55**	0.19	0.27**	0.13	0.32**	0.28**	0.32**
Q8	lessons interesting (s)								1.00	0.10	0.18*	0.15	0.34**	0.33**	0.37**
Q9	Subject easy (s)									1.00	0.27**	0.06	0.07	-0.04	0.13
Q10	Course easy (u)										1.00	0.52**	0.34**	0.22*	0.26**
Q11	I cope well (u)											1.00	0.40**	0.33**	0.44**
Q12	It is "my" subject (u)												1.00	0.34**	0.41**
Q13	growing intellectually (u)													1.00	0.40**
Q14	I enjoy subject (u)														1.00

** Correlation is significant at the 1% level (2-tailed).
* Correlation is significant at the 5% level (2-tailed).

Correlation (Kendall's tau_b) – **Females , N= 28 (level 1 97/98)**

		Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q13	Q14
Q1	like teacher (s)	1.00	0.01	0.02	-0.14	0.11	-0.02	0.63**	0.57**	0.36*	0.08	0.02	0.12	-0.18	-0.13
Q2	obtain skills (u)		1.00	0.61**	0.24	0.07	0.13	0.10	0.20	-0.10	0.15	0.37*	0.30	0.35*	0.36*
Q3	lectures interesting (u)			1.00	0.03	0.09	0.18	0.14	0.15	-0.11	0.22	0.24	0.33*	0.41*	0.29
Q4	Labs. Interesting (u)				1.00	0.29	0.12	0.07	0.07	-0.02	-0.13	0.24	0.20	0.43*	0.40*
Q5	course too mathematical (u)					1.00	0.50**	0.10	0.08	0.01	-0.28	-0.20	0.11	-0.01	0.19
Q6	course too demanding (u)						1.00	0.13	0.10	-0.16	-0.29	-0.13	0.12	-0.01	0.19
Q7	like lessons (s)							1.00	0.62**	0.25	0.18	0.10	0.32	0.01	0.00
Q8	lessons interesting (s)								1.00	0.43*	0.09	0.04	0.11	0.08	0.11
Q9	Subject easy (s)									1.00	0.20	0.08	0.00	0.09	-0.06
Q10	Course easy (u)										1.00	0.37*	0.40*	0.46**	0.13
Q11	I cope well (u)											1.00	0.36*	0.61**	0.30
Q12	It is "my" subject (u)												1.00	0.45**	0.47**
Q13	growing intellectually (u)													1.00	0.52**
Q14	I enjoy subject (u)														1.00

** Correlation is significant at the 1% level (2-tailed).
* Correlation is significant at the 5% level (2-tailed).

Appendix L

Students attitudes towards university Physics course

How did you find the Physics course at the University?

Lectures boring	☐ ☐ ☐ ☐ ☐ ☐	Lectures interesting
Laboratories interesting	☐ ☐ ☐ ☐ ☐ ☐	Laboratories boring
Tutorials helpful	☐ ☐ ☐ ☐ ☐ ☐	Tutorials waste of time
Course too mathematical	☐ ☐ ☐ ☐ ☐ ☐	Course not mathematical enough
Course difficult	☐ ☐ ☐ ☐ ☐ ☐	Course easy
Work level demanding	☐ ☐ ☐ ☐ ☐ ☐	Work level undemanding

Level 1 : males (N=132) and females (33)

	positive %	**neutral %**	**negative %**		
gender/ statements	lectures interesting	☐ ☐	lectures boring	χ^2	df
Females (N=33)	27	66	6		
Males (N=132)	22	55	22	2.48	1
	laboratories interesting	☐ ☐	laboratories boring		
Females (N=33)	24	55	18		
Males (N=132)	29	42	29	2.19	2
	tutorials helpful	☐ ☐	tutorials waste of time		
Females (N=33)	42	42	12		
Males (N=132)	35	55	10	1.07	2
	course too mathematical		course not mathematical enough		
Females (N=33)	18	63	12		
Males (N=132)	11	73	15	1.76	2
	course easy	☐ ☐	course difficult		
Females (N=33)	3	39	57		
Males (N=132)	6	58	36	4.48*	1
	work level demanding	☐ ☐	work level undemanding		
Females (N=33)	51	54	0		
Males (N=132)	31	63	5	4.33*	1

* means significance at 5% level of probability
** means significance at 1% level of probability

note: in some cases df=1 and in some cases df=2. The lower degree of freedom is used to avoid frequencies less then 4; in such cases positive and negative frequencies of responses were compared.

How did you find the Physics course at the University?

Lectures boring	▢ ▢ ▢ ▢ ▢ ▢	Lectures interesting
Laboratories interesting	▢ ▢ ▢ ▢ ▢ ▢	Laboratories boring
Tutorials helpful	▢ ▢ ▢ ▢ ▢ ▢	Tutorials waste of time
Course too mathematical	▢ ▢ ▢ ▢ ▢ ▢	Course not mathematical enough
Course difficult	▢ ▢ ▢ ▢ ▢ ▢	Course easy
Work level demanding	▢ ▢ ▢ ▢ ▢ ▢	Work level undemanding

Level 1: Group I (N=109) - students going to take physics for degree
Group II (N=56) - students going to take not physics degree.

	positive %	**neutral %**	**negative %**		
gender/ statements	lectures interesting	▢ ▢	lectures boring	χ^2	df
Group I (N=109)	20	61	19		
Group II (N=56)	16	66	18	0.48	2
	laboratories interesting	▢ ▢	laboratories boring		
Group I (N=109)	31	47	22		
Group II (N=56)	20	44	36	4.43	2
	tutorials helpful	▢ ▢	waste of time		
Group I (N=109)	40	46	14		
Group II (N=56)	30	45	25	3.67	2
	course too mathematical	▢ ▢	course not mathematical enough		
Group I (N=109)	14	74	11		
Group II (N=56)	9	70	21	3.38	2
	course easy	▢ ▢	course difficult		
Group I (N=109)	5	52	43		
Group II (N=56)	5	61	34	1.30	1
	work level demanding	▢ ▢	work level undemanding		
Group I (N=109)	38	50	3		
Group II (N=56)	34	61	5	1.18	1

note: in some cases df=1 and in some cases df=2. The lower degree of freedom is used to avoid frequencies less then 4; in such cases positive and negative frequencies of responses were compared.

How did you find the Physics course at the University?

Lectures boring	▢ ▢ ▢ ▢ ▢ ▢	Lectures interesting
Laboratories interesting	▢ ▢ ▢ ▢ ▢ ▢	Laboratories boring
Tutorials helpful	▢ ▢ ▢ ▢ ▢ ▢	Tutorials waste of time
Course too mathematical	▢ ▢ ▢ ▢ ▢ ▢	Course not mathematical enough
Course difficult	▢ ▢ ▢ ▢ ▢ ▢	Course easy
Work level demanding	▢ ▢ ▢ ▢ ▢ ▢	Work level undemanding

Level 2: males (N=43)
females (N=10)

	positive %	**neutral** %	**negative** %		
gender/ statements	lectures interesting	▢ ▢	lectures boring	χ^2	df
Females (N=10)	40	50	10		
Males (N=43)	33	48	19	0.04	1
	laboratories interesting	▢ ▢	laboratories boring		
Females (N=10)	10	70	20		
Males (N=43)	37	39	21	0.01	1
	tutorials helpful	▢ ▢	waste of time		
Females (N=10)	90	10	0		
Males (N=43)	63	25	9	-	
	course too mathematical	▢ ▢	course not mathematical enough		
Females (N=10)	0	80	20		
Males (N=43)	21	72	5	0.18	1
	course easy	▢ ▢	course difficult		
Females (N=10)	0	80	20		
Males (N=43)	0	48	49	-	
	work level demanding	▢ ▢	work level undemanding		
Females (N=10)	30	70	0		
Males (N=43)	44	47	5	-	

How did you find the Physics course at the University?

Lectures boring	☐ ☐ ☐ ☐ ☐ ☐	Lectures interesting
Laboratories interesting	☐ ☐ ☐ ☐ ☐ ☐	Laboratories boring
Tutorials helpful	☐ ☐ ☐ ☐ ☐ ☐	Tutorials waste of time
Course too mathematical	☐ ☐ ☐ ☐ ☐ ☐	Course not mathematical enough
Course difficult	☐ ☐ ☐ ☐ ☐ ☐	Course easy
Work level demanding	☐ ☐ ☐ ☐ ☐ ☐	Work level undemanding

- **Level 1** : N=165
- Level 2 : N=53

	positive %	**neutral** %	**negative** %		
statements	lectures interesting	☐ ☐	lectures boring	χ^2	df
Level 1	17	60 →	19		
Level 2	34	← 49	17	6.22*	2
	laboratories interesting	☐ ☐	laboratories boring		
Level 1	27	43 →	27		
Level 2	42	← 37	21	3.64	2
	tutorials helpful	☐ ☐	tutorials waste of time		
Level 1	37	45	18		
Level 2	68	23	8	15.56**	2
	course too mathematical	☐ ☐	course not mathematical enough		
Level 1	12	72	14		
Level 2	17	74	8	2.04	2
	course easy	☐ ☐	course difficult		
Level 1	5	55	39		
Level 2	0	53	44	-	
	work level demanding	☐ ☐	work level undemanding		
Level 1	37	56	5		
Level 2	41	51	4	-	

* means significance at 5% level of probability
** means significance at 1% level of probability

note: in some cases df=1 and in some cases df=2. The lower degree of freedom is used to avoid frequencies less then 4; in such cases positive and negative frequencies of responses were compared.

How did you find the Physics course at the University?

Lectures boring	▢ ▢ ▢ ▢ ▢ ▢	Lectures interesting
Laboratories interesting	▢ ▢ ▢ ▢ ▢ ▢	Laboratories boring
Tutorials helpful	▢ ▢ ▢ ▢ ▢ ▢	Tutorials waste of time
Course too mathematical	▢ ▢ ▢ ▢ ▢ ▢	Course not mathematical enough
Course difficult	▢ ▢ ▢ ▢ ▢ ▢	Course easy
Work level demanding	▢ ▢ ▢ ▢ ▢ ▢	Work level undemanding

- Group I : N=109
- Level 2 : N=53

	positive %	**neutral** %	**negative** %		
statements	lectures interesting	▢ ▢	lectures boring	χ^2	df
Group I	20	61	19		
Level 2	34	← 49	17	3.82	2
	laboratories interesting	▢ ▢	laboratories boring		
Group I	31	47	22		
Level 2	42	← 37	21	2.07	2
	tutorials helpful	▢ ▢	tutorials waste of time		
Group I	40	46	14		
Level 2	68	23	8	11.69**	2
	course too mathematical		course not mathematical enough		
Group I	14	74	11		
Level 2	17	74	8	0.53	2
	course easy	▢ ▢	course difficult		
Group I	5	52	43		
Level 2	0	53	44	0.08	1
	work level demanding	▢ ▢	work level undemanding		
Group I	38	50	3		
Level 2	41	51	4	0.10	2

* means significance at 5% level of probability
** means significance at 1% level of probability

note: in some cases df=1 and in some cases df=2. The lower degree of freedom is used to avoid frequencies less then 4; in such cases positive and negative frequencies of responses were compared.

Appendix M

Students' perceptions of self in the university Physics course

What are your opinions about University Physics?

I feel I am coping well	□ □ □ □ □ □	I feel I am not coping well
I am not enjoying subject	□ □ □ □ □ □	I am enjoying subject
I found subject is very easy	□ □ □ □ □ □	I found subject is very hard
I am growing intellectually	□ □ □ □ □ □	I am not growing intellectually
I am not obtaining new skills	□ □ □ □ □ □	I am obtaining new skills
I am enjoying practical work	□ □ □ □ □ □	I am not enjoying practical work
I am getting worse at subject	□ □ □ □ □ □	I am getting better at subject
It is definitely "my" subject	□ □ □ □ □ □	I am wasting time in this subject

Level 1: males (N=132) and females (33)

	positive, %	**neutral, %**	**negative, %**		
gender/ statements	I feel I am coping well	□ □	I feel I am not coping well	χ^2	df
Females (N=33)	27	57	15		
Males (N=132)	37	45	18	1.62	2
	I am enjoying subject	□ □	I am not enjoying subject		
Females (N=33)	9	66	21		
Males (N=132)	32	50	18	1.90	1
	I found subject is very easy	□ □	I found subject is hard		
Females (N=33)	0	45	64		
Males (N=132)	6	56	38	2.55	1
	I am growing intellectually	□ □	I am not growing intellectually		
Females (N=33)	15	85	0		
Males (N=132)	40	50	10	7.39**	1
	I am obtaining a lot of new skills	□ □	I am not obtaining a lot of new skills		
Females (N=33)	24	70	6		
Males (N=132)	33	52	15	0.85	1
	I am enjoying practical work	□ □	I hate practical work		
Females (N=33)	21	45	32		
Males (N=132)	30	45	25	1.25	2
	I am getting better at the subject	□ □	I am getting worse at the subject		
Females (N=33)	33	58	9		
Males (N=132)	34	55	8	0.19	1
	It is definitely "my" subject	□ □	I am wasting time in this subject		
Females (N=33)	15	73	12		
Males (N=132)	26	56	18	3.19	2

* means significance at 5% level of probability
** means significance at 1% level of probability

note: in some cases df=1 and in some cases df=2. The lower degree of freedom is used to avoid frequencies less then 4; in such cases positive and negative frequencies of responses were compared.

Level 1: Group I (N=109) - students planning to take Physics for a degree
Group II (N=56) - students not planning to take not Physics for a degree.

	positive, %	**neutral, %**	**negative, %**		
groups/ statements	I feel I am coping well	□ □	I feel I am not coping well	χ^2	df
Group I (N=109)	37	46	17		
Group II (N=56)	25	57	18	2.53	2
	I am enjoying subject	□ □	I am not enjoying subject		
Group I (N=109)	30	57	13		
Group II (N=56)	11	82	7	9.61**	1
	I found subject is very easy	□ □	I found subject is hard		
Group I (N=109)	5	55	40		
Group II (N=56)	7	51	42	0.41	1
	I am growing intellectually	□ □	I am not growing intellectually		
Group I (N=109)	37	48	15		
Group II (N=56)	21	63	16	4.59	2
	I am obtaining a lot of new skills	□ □	I am not obtaining a lot of new skills		
Group I (N=109)	37	49	14		
Group II (N=56)	20	69	11	6.33*	2
	I am enjoying practical work	□ □	I hate practical work		
Group I (N=109)	31	48	21		
Group II (N=56)	23	33	43	8.8*	2
	I am getting better at the subject	□ □	I am getting worse at the subject		
Group I (N=109)	48	46	6		
Group II (N=56)	38	51	11	2.21	2
	It is definitely "my" subject	□ □	I am wasting time in this subject		
Group I (N=109)	33	53	14		
Group II (N=56)	7	63	30	15.87**	2

* means significance at 5% level of probability
** means significance at 1% level of probability

note: in some cases df=1 and in some cases df=2. The lower degree of freedom is used to avoid frequencies less then 4; in such cases positive and negative frequencies of responses were compared.

Level 2: males (N=43), females (N=10)

gender/ statements	positive %	neutral %	negative %	χ^2	df
	I feel I am coping well	▢ ▢	I feel I am not coping well		
Females (N=10)	70	30	0		
Males (N=43)	51	37	12	-	
	I am enjoying subject	▢ ▢	I am not enjoying subject		
Females (N=10)	70	30	0		
Males (N=43)	47	44	7	-	
	I found subject is very easy	▢ ▢	I found subject is hard		
Females (N=10)	0	80	20		
Males (N=43)	7	46	44	1.07	1
	I am growing intellectually	▢ ▢	I am not growing intellectually		
Females (N=10)	70	30	0		
Males (N=43)	51	40	6	-	
	I am obtaining a lot of new skills	▢ ▢	I am not obtaining a lot of new skills		
Females (N=10)	60	40	0		
Males (N=43)	45	47	7	-	
	I am enjoying practical work	▢ ▢	I hate practical work		
Females (N=10)	20	60	20		
Males (N=43)	38	57	3	-	
	I am getting better at the subject	▢ ▢	I am getting worse at the subject		
Females (N=10)	80	20	0		
Males (N=43)	63	37	0	-	
	It is definitely "my" subject	▢ ▢	I am wasting time in this subject		
Females (N=10)	60	40	0		
Males (N=43)	49	42	8	-	

note: due to small sample of level 2 females some statistical analyses were impossible to do.

Level 1: N=165
Level 2: N=53

	positive %	neutral %	negative %		
statements	I feel I am coping well	▢ ▢	I feel I am not coping well	χ^2	df
Level 1	36	47	17		
Level 2	55	35	10	6.16*	2
	I am enjoying subject	▢ ▢	I am not enjoying subject		
Level 1	28	52	19		
Level 2	52	42	6	8.56*	2
	I found subject is very easy	▢ ▢	I found subject is hard		
Level 1	5	53	42		
Level 2	6	53	41	0.01	
	I am growing intellectually	▢ ▢	I am not growing intellectually		
Level 1	35	59	5		
Level 2	55	39	4	4.22*	1
	I am obtaining a lot of new skills	▢ ▢	I am not obtaining a lot of new skills		
Level 1	31	46	13		
Level 2	48	46	6	5.78	2
	I am enjoying practical work	▢ ▢	I hate practical work		
Level 1	28	43	27		
Level 2	41	51	4	23.11**	1
	I am getting better at the subject	▢ ▢	I am getting worse at the subject		
Level 1	32	58	8		
Level 2	66	33	0	14.68**	1
	It is definitely "my" subject	▢ ▢	I am wasting time in this subject		
Level 1	24	59	17		
Level 2	51	42	7	11.68**	2

* means significance at 5% level of probability
** means significance at 1% level of probability

note: in some cases df=1 and in some cases df=2. The lower degree of freedom is used to avoid frequencies less then 4; in such cases positive and negative frequencies of responses were compared.

Appendix N

Students' attitudes towards organisation of the Physics course

Appendix N:
Students' evaluations of organisation of the Physics course

Thinking about your Physics course, tick the boxes below to reflect your opinions

	Strongly agree	Agree	Disagree	Strongly disagree
I found the course well organized	☐	☐	☐	☐
I felt the assessment methods used were good	☐	☐	☐	☐
The time demand was not reasonable for me	☐	☐	☐	☐
I found a good support from the academic staff	☐	☐	☐	☐
I think there will be poor career opportunities	☐	☐	☐	☐

Level 1:

	Females N=33	**Males N=132**
1. I found the course well organized	%	%
strongly agree	15	20
agree	85	74
disagree	0	5
strongly disagree	0	1
2. I felt the assessment methods used were good		
strongly agree	12	14
agree	76	74
disagree	12	12
strongly disagree	0	0
3. The time demand was NOT reasonable for me		
strongly agree	3	5
agree	30	32
disagree	64	60
strongly disagree	3	3
4. I found a good support from the academic staff		
strongly agree	0	14
agree	76	54
disagree	24	24
strongly disagree	0	3
5. I think there will be poor career opportunities		
strongly agree	0	5
agree	18	14
disagree	73	56
strongly disagree	6	20

Thinking about your Physics course, tick the boxes below to reflect your opinions

	Strongly agree	Agree	Disagree	Strongly disagree
I found the course well organized	☐	☐	☐	☐
I felt the assessment methods used were good	☐	☐	☐	☐
The time demand was not reasonable for me	☐	☐	☐	☐
I found a good support from the academic staff	☐	☐	☐	☐
I think there will be poor career opportunities	☐	☐	☐	☐

Level 2:

	Females N=10	**Males N=43**
1. I found the course well organized	%	%
strongly agree	30	23
agree	70	68
disagree	0	7
strongly disagree	0	0
2. I felt the assessment methods used were good		
strongly agree	20	7
agree	80	79
disagree	0	14
strongly disagree	0	0
3. The time demand was NOT reasonable for me		
strongly agree	0	9
agree	30	26
disagree	50	61
strongly disagree	20	2
4. I found a good support from the academic staff		
strongly agree		
agree		
disagree		
strongly disagree		
5. I think there will be poor career opportunities		
strongly agree	10	2
agree	80	23
disagree	10	42
strongly disagree	0	26

Thinking about your Physics course, tick the boxes below to reflect your opinions

	Strongly agree	Agree	Disagree	Strongly disagree
I found the course well organized	☐	☐	☐	☐
I felt the assessment methods used were good	☐	☐	☐	☐
The time demand was not reasonable for me	☐	☐	☐	☐
I found a good support from the academic staff	☐	☐	☐	☐
I think there will be poor career opportunities	☐	☐	☐	☐

	Level 1	**Level 2**
	N=165	**N=53**
1. found the course well organized	%	%
strongly agree	19	25
agree	75	68
disagree	5	6
strongly disagree	1	0
2. I felt the assessment methods used were good		
strongly agree	15	10
agree	75	79
disagree	10	11
strongly disagree	0	0
3. The time demand was NOT reasonable for me		
strongly agree	4	9
agree	32	26
disagree	61	59
strongly disagree	2	6
4. I found a good support from the academic staff (**)		
strongly agree	11	27
agree	63	64
disagree	24	8
strongly disagree	2	0
5. I think there will be poor career opportunities (***)		
strongly agree	4	4
agree	15	34
disagree	60	36
strongly disagree	17	21

** marks the statistically significant difference; chi-square obtained equal 8.62, significant at 1% level of probability, df=1

*** marks the statistically significant difference; chi-square obtained equal 8.03, significant at 1% level of probability, df=1

Appendix O

Students' expectations from and their fulfilment by the Physics course

Which factor(s) influenced your choice of planned Honours subject(s)?

	Level 1				Level 2			
	Female (N=33) %	Male (N=132) %	χ^2	df	Female (N=10) %	Male (N=43) %	χ^2	df
Enjoyment of subject	91	88	0.24	1	90	81	0.43	1
Good grades at school	67	80	2.47	1	40	70	-	
Your teacher at school	24	28	0.19	1	20	30	-	
Your parents	3	5	-		10	9	-	
Information from mass media	6	10	-		0	0	-	
Friends	3	5	-		0	5	-	
Likely career opportunities	55	50	0.22	1	50	40	0.37	1
Demonstrations, exhibitions, festivals	6	14	-		0	9	-	

Why did you choose Glasgow University?

- ☐ Only University which offered me a place
- ☐ Best one for subject(s) I anted to study
- ☐ Only University which runs the course(s) I wanted to take
- ☐ University seemed to offer excellent extra facilities
- ☐ Good academic reputation
- ☐ Near my home
- ☐ No other choices for me
- ☐ Recommended to me

	Level 1			**Level 2**			**both courses**		
	Female (N=33) %	Male (N=132) %	χ^2	Female (N=10) %	Male (N=43) %	χ^2	Level 1 (N=165) %	Level 2 (N=53) %	χ^2
Only University which offered me a place	0	3	-	0	0	-	3	0	-
Best one for subject(s) I anted to study	58	53	0.22	70	44	-	54	49	0.38
Only University which runs the course(s) I wanted to take	15	12	0.22	20	5	-	13	7.5	-
University seemed to offer excellent extra facilities	33	39	0.41	10	35	-	38	30	1.11
Good academic reputation	91	83	-	70	81	-	84	79	0.71
Near my home	67	67	1.78	50	49	0.01	56	49	0.87
No other choices for me	0	0	-	0	2.3	-	1.2	2	-
Recommended to me	30	30	0.03	20	30	-	32	28	0.19

note: 1) due to small frequency of responses there was impossible to calculate chi-square for some statements. In those cases the value of chi-square is missed in the table.
2) df=1

Appendix O:
Students expectations from and their fulfilment by the University Physics course

Before coming to Glasgow University, what were your **expectations** from the Physics course?

- ☐ developing new or existing skills
- ☐ increasing my self-confidence in Physics
- ☐ preparing for a career
- ☐ experiencing intellectual growth
- ☐ having a good time
- ☐ deeper understanding of subject
- ☐ learning about new ideas
- ☐ broadening my horizon
- ☐ obtaining practical skills
- ☐ meeting new people

Expectations/ expectations fulfilled

	Level 1: Males (N=132)			**Level 1: Females (N=33)**		
	expectations, %	fulfilled expectations, %	χ^2	expectations, %	Fulfilled expectations, %	χ^2
developing new or existing skills	66	51	6.12*	42	33	0.57
increasing my self-confidence in Physics	45	27	9.28**	36	18	2.71
preparing for a career	48	25	15.06**	64	24	10.71**
experiencing intellectual growth	61	44	7.65**	27	21	0.32
having a good time	30	20	3.52	30	27	0.07
deeper understanding of subject	86	61	21.17**	79	52	5.32*
learning about new ideas	73	52	12.41**	67	55	0.99
broadening my horizon	49	35	5.31*	45	36	0.56
obtaining practical skills	53	37	6.83**	36	21	1.82
meeting new people	47	34	4.63*	58	45	1.12

df=1 for every option suggested
* means significance at 5% level of probability
** means significance at 1% level of probability

Before coming to Glasgow University, what were your **expectations** from the Physics course?

- ☐ developing new or existing skills
- ☐ increasing my self-confidence in Physics
- ☐ preparing for a career
- ☐ experiencing intellectual growth
- ☐ having a good time
- ☐ deeper understanding of subject
- ☐ learning about new ideas
- ☐ broadening my horizon
- ☐ obtaining practical skills
- ☐ meeting new people

Expectations/ Expectations fulfilled

	Level 1: Group I (N=109)			**Level 1: Group II (N=56)**		
	expectations, %	fulfilled expectations, %	χ^2	expectations, %	fulfilled expectations, %	χ^2
developing new or existing skills	68	52	5.81*	48	38	1.14
increasing my self-confidence in Physics	50	28	11.08**	27	20	0.76
preparing for a career	63	28	26.9**	27	13	3.43
experiencing intellectual growth	54	39	4.92*	55	41	2.19
having a good time	39	28	2.96	13	13	0
deeper understanding of subject	87	70	9.33**	82	55	9.46**
learning about new ideas	71	52	8.31**	75	52	6.39*
broadening my horizon	54	41	3.84*	36	23	2.76
obtaining practical skills	55	36	7.93**	41	31	1.22
meeting new people	62	45	6.31*	23	13	1.91

df=1 for every option suggested
* means significance at 5% level of probability
** means significance at 1% level of probability

Before coming to Glasgow University, what were your **expectations** from the Physics course?

- ☐ developing new or existing skills
- ☐ increasing my self-confidence in Physics
- ☐ preparing for a career
- ☐ experiencing intellectual growth
- ☐ having a good time
- ☐ deeper understanding of subject
- ☐ learning about new ideas
- ☐ broadening my horizon
- ☐ obtaining practical skills
- ☐ meeting new people

Expectations/ Expectations fulfilled

	Level 2: Males (N=43)			**Level 2: Females (N=10)**		
	expectations, %	fulfilled expectations, %	χ^2	expectations, %	fulfilled expectations, %	χ^2
developing new or existing skills	70	53	2.62	90	90	0
increasing my self-confidence in Physics	35	30	0.25	30	30	0
preparing for a career	67	35	8.8**	80	50	1.97
experiencing intellectual growth	74	51	4.85*	50	40	-
having a good time	30	23	0.54	40	40	0
deeper understanding of subject	88	58	9.82**	80	80	0
learning about new ideas	60	42	2.79	90	90	0
broadening my horizon	60	40	3.44	60	30	1.82
obtaining practical skills	56	37	3.12	40	20	0.95
meeting new people	33	21	1.57	80	80	0

df=1 for every option suggested
* means significance at 5% level of probability
** means significance at 1% level of probability

Before coming to Glasgow University, what were your **expectations** from the Physics course?

- ☐ developing new or existing skills
- ☐ increasing my self-confidence in Physics
- ☐ preparing for a career
- ☐ experiencing intellectual growth
- ☐ having a good time
- ☐ deeper understanding of subject
- ☐ learning about new ideas
- ☐ broadening my horizon
- ☐ obtaining practical skills
- ☐ meeting new people

Expectations/ Expectations fulfilled

	Level 1, N=165			**Level 2, N=53**		
	expectations, %	fulfilled expectations, %	χ^2	expectations, %	fulfilled expectations, %	χ^2
developing new or existing skills	61	47	6.51*	74	60	2.35
increasing my self-confidence in Physics	42	25	10.7**	34	30	0.19
preparing for a career	51	25	23.67**	70	38	10.9**
experiencing intellectual growth	54	39	7.46**	70	49	4.85*
having a good time	30	22	2.71	32	26	0.48
deeper understanding of subject	85	68	11.58**	87	60	9.92**
learning about new ideas	72	52	14.01**	66	51	2.46
broadening my horizon	48	35	5.74*	60	38	5.13*
obtaining practical skills	50	34	8.66**	53	34	3.89*
meeting new people	49	37	4.85*	42	32	1.14

df=1 for every option suggested
* means significance at 5% level of probability
** means significance at 1% level of probability

Appendix O:
Students expectations from and their fulfilment by the University Physics course

Before coming to Glasgow University, what were your ***expectations*** *from the Physics course?*

- ☐ developing new or existing skills
- ☐ increasing my self-confidence in Physics
- ☐ preparing for a career
- ☐ experiencing intellectual growth
- ☐ having a good time
- ☐ deeper understanding of subject
- ☐ learning about new ideas
- ☐ broadening my horizon
- ☐ obtaining practical skills
- ☐ meeting new people

	Level 1			**Level 1**			**Level 2**		
	Female (N=33) %	Male (N=132) %	χ^2	Group I (N=109) %	Group II (N=56) %	χ^2	Female (N=33) %	Male (N=132) %	χ^2
developing new or existing skills	42	66	6.41*	72	48	6.10*	90	70	1.7
increasing my self-confidence in Physics	36	45	0.87	52	27	7.58**	30	35	0.08
preparing for a career	64	48	2.71	61	27	13.63**	80	67	0.61
experiencing intellectual growth	27	61	12.29**	56	55	0.01	50	74	2.30
having a good time	30	30	0	39	13	11.99**	40	30	0.36
deeper understanding of subject	79	86	0.93	87	82	0.75	80	88	0.50
learning about new ideas	67	73	0.99	69	75	0.49	90	60	3.16
broadening my horizon	45	49	0.17	56	36	4.4*	60	60	0
obtaining practical skills	36	53	3.05	54	41	1.81	40	56	0.81
meeting new people	58	47	1.27	61	23	17.95**	80	33	7.52**

df=1 for every option suggested
* means significance at 5% level of probability
** means significance at 1% level of probability

Expectations from the university physics course which **have been fulfilled**.

- ▢ developing new or existing skills
- ▢ increasing my self-confidence in Physics
- ▢ preparing for a career
- ▢ experiencing intellectual growth
- ▢ having a good time
- ▢ deeper understanding of subject
- ▢ learning about new ideas
- ▢ broadening my horizon
- ▢ obtaining practical skills
- ▢ meeting new people

		Level 1			Level 1			Level 2		
		Female (N=33) %	Male (N=132) %	χ^2	Group I (N=109) %	Group II (N=56) %	χ^2	Female (N=10) %	Male (N=43) %	χ^2
1	developing new or existing skills	33	51	3.43	52	38	2.91	90	53	4.52*
2	increasing my self-confidence in Physics	18	27	1.15	28	20	1.25	30	30	0
3	preparing for a career	24	25	0	28	13	4.71*	50	35	0.79
4	experiencing intellectual growth	21	44	5.84*	39	41	0.06	40	51	0.49
5	having a good time	27	20	0.77	28	13	4.71*	40	23	1.17
6	deeper understanding of subject	52	61	0.9	70	55	3.65	80	58	1.65
7	learning about new ideas	55	52	0.01	52	52	0	90	42	7.52*
8	broadening my horizon	36	35	0.03	41	23	5.27*	30	40	0.31
9	obtaining practical skills	21	37	2.98	36	31	0.41	20	37	1.07
10	meeting new people	45	34	1.47	45	13	16.84**	80	21	12.99**

df=1 for every option suggested
* means significance at 5% level of probability
** means significance at 1% level of probability

Appendix O:
Students expectations from and their fulfilment by the University Physics course

fulfilled expectations

	Statements suggested	Level 1 (N=165) %	Level 2 (N=53) %	χ^2
1	deeper understanding of subject	68	60	1.15
2	learning about new ideas	52	51	0.02
3	developing new or existing skills	47	60	2.71
4	experiencing intellectual growth	39	49	1.65
5	meeting new people	37	32	0.44
6	broadening my horizon	35	38	0.16
7	obtaining practical skills	34	34	0
8	increasing my self-confidence in Physics	25	30	0.52
9	preparing for a career	25	38	3.35
10	having a good time	22	26	0.36

df=1 and * means significance at 5% level of probability

<u>Expectations</u> from the Physics course which **<u>have NOT been fulfilled</u>**.

- ▢ developing new or existing skills
- ▢ increasing my self-confidence in Physics
- ▢ preparing for a career
- ▢ experiencing intellectual growth
- ▢ having a good time
- ▢ deeper understanding of subject
- ▢ learning about new ideas
- ▢ broadening my horizon
- ▢ obtaining practical skills
- ▢ meeting new people

		Level 1			Level 1			Level 2		
		Female (N=33) %	Male (N=132) %	χ^2	Group I (N=109) %	Group II (N=56) %	χ^2	Female (N=33) %	Male (N=132) %	χ^2
1	developing new or existing skills	9	14	-	16	7	-	0	0	-
2	increasing my self-confidence in Physics	18	15	0.18	20	7	-	0	5	-
3	preparing for a career	33	20	2.82	27	14	3.23	30	16	-
4	experiencing intellectual growth	6	13	-	13	9	0.56	10	0	-
5	having a good time	3	10	-	12	2	-	0	2	-
6	deeper understanding of subject	21	15	0.71	17	14	0.27	0	7	-
7	learning about new ideas	3	17	-	14	14	0	0	2	-
8	broadening my horizon	9	13	-	14	9	0.81	20	0	-
9	obtaining practical skills	6	14	-	14	9	0.81	20	2	-
10	meeting new people	13	8	0.8	15	6	-	0	0	-

df=1 for every option suggested
* means significance at 5% level of probability
** means significance at 1% level of probability

Appendix O:
Students expectations from and their fulfilment by the University Physics course

aspirations that have NOT been fulfilled in the university physics course

No.	1st course	%	2nd course	%
1.	preparing for a career	23	preparing for a career	19
2.	deeper understanding of subject	16	deeper understanding of subject	6
3.	increasing my self-confidence in Physics	16	obtaining practical skills	6
4.	learning about new ideas	14	broadening my horizon	4
5.	developing new or existing skills	13	increasing my self-confidence in Physics	4
6.	broadening my horizon obtaining practical skills meeting new people	12	experiencing intellectual growth having a good time learning about new ideas	2
7.	experiencing intellectual growth	12	developing new or existing skills	0
8.	having good time	9	meeting new people	0

Appendix P

Students' attitudes towards school Physics course

What are your opinions about your ***school Physics course****?*

I liked Physics	▢ ▢ ▢ ▢ ▢ ▢	I hated Physics
boring subject	▢ ▢ ▢ ▢ ▢ ▢	interesting subject
easy subject	▢ ▢ ▢ ▢ ▢ ▢	complicated subject
prepared me well for University	▢ ▢ ▢ ▢ ▢ ▢	prepared me badly for University
I dislike the teacher	▢ ▢ ▢ ▢ ▢ ▢	I like the teacher
Enjoying subject	▢ ▢ ▢ ▢ ▢ ▢	boring subject

Level 1 : males (N=132) and females (33)

	positive %	**neutral %**	**negative %**		
gender/ statements	I liked Physics	▢ ▢	I hated Physics	χ^2	df
Females (N=33)	87	12	0	1.27	1
Males (N=132)	78	19	3		
	interesting subject	▢ ▢	boring subject		
Females (N=33)	84	14	0		
Males (N=132)	66	26	7	0.39	1
	easy subject	▢ ▢	difficult subject		
Females (N=33)	24	48	27		
Males (N=132)	32	50	17	1.9	2
	prepared me well for University	▢ ▢	prepared me badly for University		
Females (N=33)	51	46	3		
Males (N=132)	48	35	14	0.02	1
	I liked the teacher	▢ ▢	I disliked the teacher		
Females (N=33)	85	9	6		
Males (N=132)	62	20	13	4.35*	1
	enjoying subject	▢ ▢	boring subject		
Females (N=33)	72	18	6		
Males (N=132)	48	39	10	6.67**	1

* means significance at 5% level of probability
** means significance at 1% level of probability

note: in some cases df=1 and in some cases df=2. The lower degree of freedom is used to avoid frequencies less then 4; in such cases positive and negative frequencies of responses the were compared.

What are your opinions about your ***school Physics course****?*

I liked Physics	▢ ▢ ▢ ▢ ▢ ▢	I hated Physics
boring subject	▢ ▢ ▢ ▢ ▢ ▢	interesting subject
easy subject	▢ ▢ ▢ ▢ ▢ ▢	complicated subject
prepared me well for University	▢ ▢ ▢ ▢ ▢ ▢	prepared me badly for University
I dislike the teacher	▢ ▢ ▢ ▢ ▢ ▢	I like the teacher
enjoying subject	▢ ▢ ▢ ▢ ▢ ▢	boring subject

Level 1 : Group I (N=109) and Group II (N=56)

	positive %	**neutral %**	**negative %**		
gender/ statements	I liked Physics	▢ ▢	I hated Physics	χ^2	df
Group I (N=109)	85	15	0		
Group II (N=56)	71	20	9	11.7**	1
	interesting subject	▢ ▢	boring subject		
Group I (N=109)	74	24	2		
Group II (N=56)	68	21	11	0.76	1
	easy subject	▢ ▢	difficult subject		
Group I (N=109)	33	46	21		
Group II (N=56)	27	57	16	1.89	2
	prepared me well for University	▢ ▢	prepared me badly for University		
Group I (N=109)	50	42	8		
Group II (N=56)	48	32	20	4.93	2
	I liked the teacher	▢ ▢	I disliked the teacher		
Group I (N=109)	70	17	13		
Group II (N=56)	70	23	7	1.97	2
	enjoying subject	▢ ▢	boring subject		
Group I (N=109)	53	39	7		
Group II (N=56)	59	27	14	3.75	2

* means significance at 5% level of probability
** means significance at 1% level of probability

note: in some cases df=1 and in some cases df=2. The lower degree of freedom is used to avoid frequencies less then 4; in such cases positive and negative frequencies of responses the were compared.

What are your opinions about your ***school Physics course****?*

I liked Physics	▢ ▢ ▢ ▢ ▢ ▢	I hated Physics
boring subject	▢ ▢ ▢ ▢ ▢ ▢	interesting subject
easy subject	▢ ▢ ▢ ▢ ▢ ▢	complicated subject
prepared me well for University	▢ ▢ ▢ ▢ ▢ ▢	prepared me badly for University
I dislike the teacher	▢ ▢ ▢ ▢ ▢ ▢	I like the teacher
enjoying lessons	▢ ▢ ▢ ▢ ▢ ▢	boring lessons

Level 2: Females (N=10) and Males (N=43)

	positive %	**neutral %**	**negative %**		
gender/ statements	I liked Physics	▢ ▢	I hated Physics	χ^2	df
Females (N=10)	80	20	0		
Males (N=43)	89	10	0	-	
	interesting subject	▢ ▢	boring subject		
Females (N=10)	100	0	0		
Males (N=43)	72	20	2	-	
	easy subject	▢ ▢	difficult subject		
Females (N=10)	20	70	10		
Males (N=43)	10	63	26	0.07	1
	prepared me well for University	▢ ▢	prepared me badly for University		
Females (N=10)	50	30	10		
Males (N=43)	42	35	21	-	
	I liked the teacher	▢ ▢	I disliked the teacher		
Females (N=10)	100	0	0		
Males (N=43)	75	24	0	-	
	enjoying lessons	▢ ▢	boring lessons		
Females (N=10)	50	40	10	0.41	1
Males (N=43)	56	36	5		

note: in some cases df=1 and in some cases df=2. The lower degree of freedom is used to avoid frequencies less then 4; in such cases positive and negative frequencies of responses the were compared.

What are your opinions about your **school Physics course**?

I liked Physics	▢ ▢ ▢ ▢ ▢ ▢	I hated Physics
boring subject	▢ ▢ ▢ ▢ ▢ ▢	interesting subject
easy subject	▢ ▢ ▢ ▢ ▢ ▢	complicated subject
prepared me well for University	▢ ▢ ▢ ▢ ▢ ▢	prepared me badly for University
I dislike the teacher	▢ ▢ ▢ ▢ ▢ ▢	I like the teacher
enjoying lessons	▢ ▢ ▢ ▢ ▢ ▢	boring lessons

Level 1: (N=165)
Level 2: (N=53)

	positive %	**neutral %**	**negative %**		
level/ statements	I liked Physics		I hated Physics	χ^2	df
Level 1	80	17	3	-	
Level 2	87	13	0		
	interesting subject		boring subject		
Level 1	69	23	5		
Level 2	72	17	2	-	
	easy subject		difficult subject		
Level 1	31	49	19		
Level 2	12	64	23	11.6**	1
	prepared me well for University		prepared me badly for University		
Level 1	49	37	11	-	
Level 2	43	34	19		
	I liked the teacher		I disliked the teacher		
Level 1	67	18	11		
Level 2	79	19	0		
	enjoying lessons		boring lessons		
Level 1	54	35	11		
Level 2	56	36	4		

** means significance at 1% level of probability

note: in some cases df=1 and in some cases df=2. The lower degree of freedom is used to avoid frequencies less then 4; in such cases positive and negative frequencies of responses the were compared.

Appendix Q

“Withdrew students” and “Committed students”

*What are your opinions about your **school Physics course**?*

I liked Physics	▢ ▢ ▢ ▢ ▢ ▢	I hated Physics
boring subject	▢ ▢ ▢ ▢ ▢ ▢	interesting subject
easy subject	▢ ▢ ▢ ▢ ▢ ▢	complicated subject
prepared me well for University	▢ ▢ ▢ ▢ ▢ ▢	prepared me badly for University
I dislike the teacher	▢ ▢ ▢ ▢ ▢ ▢	I like the teacher
enjoying lessons	▢ ▢ ▢ ▢ ▢ ▢	boring lessons

Level 1 : Committed (N=60)
Withdrew (N=27)

	positive %	neutral %	negative %		
group/ statements	I liked Physics	▢ ▢	I hated Physics	χ^2	df
Committed	83	17	0		
Withdrew	74	26	0	0.85	1
	interesting subject		boring subject		
Committed	75	24	1		
Withdrew	65	33	2	0.83	1
	easy subject		difficult subject		
Committed	32	47	21		
Withdrew	39	43	18	0.37	2
	prepared me well for University		prepared me badly for University		
Committed	45	43	12		
Withdrew	57	36	7	1.09	2
	I liked the teacher	▢ ▢	I disliked the teacher		
Committed	63	27	10		
Withdrew	65	20	15	0.71	2
	enjoying lessons		boring lessons		
Committed	68	29	3		
Withdrew	52	39	9	1.84	1

* means significance at 5% level of probability
** means significance at 1% level of probability

note: in some cases df=1 and in some cases df=2. The lower degree of freedom is used to avoid frequencies less then 4; in such cases positive and negative frequencies of responses the were compared.

Which factor(s) influenced your choice of planned Honours subject(s)?

- ☐ Enjoyment of subject
- ☐ Good grades at school
- ☐ Your teacher at school
- ☐ Your parents
- ☐ Information from mass media
- ☐ Friends
- ☐ Likely career opportunities
- ☐ Demonstrations, exhibitions, festivals
- ☐ Any other factors (*please list below)*

____

		Committed/ Withdrew		
		Committed (N=60) %	Withdrew (N=27) %	χ^2
1	Enjoyment of subject	90	59	8.13**
2	Good grades at school	94	71	6.24**
3	Your teacher at school	37	29	0.29
4	Your parents	0	6	-
5	Information from mass media	10	12	-
6	Friends	4	6	-
7	Likely career opportunities	41	24	1.63
8	Demonstrations, exhibitions, festivals	24	12	-

df=1 for every option suggested

* means significance at 5% level of probability
** means significance at 1% level of probability

Before coming to Glasgow University, what were your **expectations** from the Physics course?

- ☐ developing new or existing skills
- ☐ increasing my self-confidence in Physics
- ☐ preparing for a career
- ☐ experiencing intellectual growth
- ☐ having a good time
- ☐ deeper understanding of subject
- ☐ learning about new ideas
- ☐ broadening my horizon
- ☐ obtaining practical skills
- ☐ meeting new people

		Committed/ Withdrew			Committed/ Level 2			Withdrew/ Level 2		
		Committed (N=60) %	Withdrew (N=27) %	χ^2	Committed (N=60) %	Level 2 (N=53) %	χ^2	Withdrew (N=27) %	Level 2 (N=53) %	χ^2
1	developing new or existing skills	75	65	0.83	75	74	0.01	65	74	0.64
2	increasing my self-confidence in Physics	53	43	0.67	53	34	4.12*	43	34	0.56
3	preparing for a career	63	52	0.84	63	70	0.62	52	70	2.27
4	experiencing intellectual growth	63	35	5.27*	63	70	0.62	35	70	8.15**
5	having a good time	38	35	0.07	38	32	0.45	35	32	0.07
6	deeper understanding of subject	85	78	0.58	85	87	0.09	78	87	0.98
7	learning about new ideas	77	61	2.14	77	66	1.68	61	66	0.18
8	broadening my horizon	62	39	3.56	62	60	0.05	39	60	2.85
9	obtaining practical skills	58	61	0.06	58	53	0.29	61	53	0.42
10	meeting new people	55	61	0.24	55	42	1.90	61	42	2.32

df=1 for every option suggested

* means significance at 5% level of probability

** means significance at 1% level of probability

Before coming to Glasgow University, what were your **expectations** from the Physics course?

- ▢ developing new or existing skills
- ▢ increasing my self-confidence in Physics
- ▢ preparing for a career
- ▢ experiencing intellectual growth
- ▢ having a good time
- ▢ deeper understanding of subject
- ▢ learning about new ideas
- ▢ broadening my horizon
- ▢ obtaining practical skills
- ▢ meeting new people

Expectations/ expectations fulfilled

	Level 1: Committed (N=60)			Level 1: Withdrew (27)		
	expectations, %	fulfilled expectations, %	χ^2	expectations, %	fulfilled expectations, %	χ^2
developing new or existing skills	75	60	3.08	65	43	2.63
increasing my self-confidence in Physics	53	33	4.90*	43	22	2.71
preparing for a career	63	38	7.50**	52	26	3.84*
experiencing intellectual growth	63	48	2.73	35	17	2.27
having a good time	38	27	1.65	35	22	1.12
deeper understanding of subject	85	67	5.32*	78	48	5.21*
learning about new ideas	77	60	4.02*	61	43	1.75
broadening my horizon	62	43	4.34*	39	26	1.04
obtaining practical skills	58	48	1.20	61	39	2.61
meeting new people	55	42	2.03	61	35	3.66

df=1 for every option suggested
* means significance at 5% level of probability
** means significance at 1% level of probability

Data for correlation

	Committed (N=60)		**Withdrew (N=23)**	
	expectations, %	fulfilled + not fulfilled, %	expectations, %	fulfilled + not fulfilled, %
developing new or existing skills	75	73	65	60
increasing my self-confidence in Physics	53	46	43	39
preparing for a career	63	60	52	52
experiencing intellectual growth	63	61	35	34
having a good time	38	39	35	31
deeper understanding of subject	85	77	78	60
learning about new ideas	77	72	61	60
broadening my horizon	62	60	39	39
obtaining practical skills	58	58	61	51
meeting new people	55	50	61	57

How did you find the Physics course at the University?

Lectures boring	▢ ▢ ▢ ▢ ▢ ▢	Lectures interesting
Laboratories interesting	▢ ▢ ▢ ▢ ▢ ▢	Laboratories boring
Tutorials helpful	▢ ▢ ▢ ▢ ▢ ▢	Tutorials waste of time
Course too mathematical	▢ ▢ ▢ ▢ ▢ ▢	Course not mathematical enough
Course difficult	▢ ▢ ▢ ▢ ▢ ▢	Course easy
Work level demanding	▢ ▢ ▢ ▢ ▢ ▢	Work level undemanding

■ **Level 1** : Committed (N=60)
Withdrew (N=27)

	positive %	neutral %	negative %		
gender/ statements	lectures interesting	▢ ▢	lectures boring	χ^2	df
Committed	25	57	18		
Withdrew	26	65	9	1.06	2
	laboratories interesting	▢ ▢	laboratories boring		
Committed	23	47	30		
Withdrew	30	48	22	0.71	2
	tutorials helpful	▢ ▢	tutorials waste of time		
Committed	17	51	32		
Withdrew	30	53	17	2.72	2
	course too mathematical		course not mathematical enough		
Committed	8	79	13		
Withdrew	17	79	4	2.57	2
	course easy	▢ ▢	course difficult		
Committed	7	66	27		
Withdrew	0	35	65	6.54*	1
	work level demanding	▢ ▢	work level undemanding		
Committed	27	68	5		
Withdrew	57	43	0	6.55*	1

* means significance at 5% level of probability
** means significance at 1% level of probability

note: in some cases df=1 and in some cases df=2. The lower degree of freedom is used to avoid frequencies less then 4; in such cases positive and negative frequencies of responses the were compared.

What are your opinions about University Physics?

I feel I am coping well	▢ ▢ ▢ ▢ ▢ ▢	I feel I am not coping well
I am not enjoying subject	▢ ▢ ▢ ▢ ▢ ▢	I am enjoying subject
I found subject is very easy	▢ ▢ ▢ ▢ ▢ ▢	I found subject is very hard
I am growing intellectually	▢ ▢ ▢ ▢ ▢ ▢	I am not growing intellectually
I am not obtaining new skills	▢ ▢ ▢ ▢ ▢ ▢	I am obtaining new skills
I am enjoying practical work	▢ ▢ ▢ ▢ ▢ ▢	I am not enjoying practical work
I am getting worse at subject	▢ ▢ ▢ ▢ ▢ ▢	I am getting better at subject
It is definitely "my" subject	▢ ▢ ▢ ▢ ▢ ▢	I am wasting time in this subject

Level 1: Committed (N=60) and Withdrew (N=27)

	positive %	**neutral** %	**negative** %		
groups/ statements	I feel I am coping well	▢ ▢	I feel I am not coping well	χ^2	df
Committed	50	43	7		
Withdrew	17	57	26	7.08*	2
	I am enjoying subject	▢ ▢	I am not enjoying subject		
Committed	43	49	8		
Withdrew	9	78	13	4.61*	1
	I found subject is very easy	▢ ▢	I found subject is hard		
Committed	17	55	28		
Withdrew	4	44	52	4.22*	1
	I am growing intellectually	▢ ▢	I am not growing intellectually		
Committed	48	40	12		
Withdrew	22	69	9	4.70*	1
	I am obtaining a lot of new skills	▢ ▢	I am not obtaining a lot of new skills		
Committed	37	60	3		
Withdrew	43	44	13	1.83	1
	I am enjoying practical work	▢ ▢	I hate practical work		
Committed	32	53	15		
Withdrew	39	31	30	3.91	2
	I am getting better at the subject	▢ ▢	I am getting worse at the subject		
Committed	62	35	3		
Withdrew	43	53	4	2.44	1
	It is definitely "my" subject	▢ ▢	I am wasting time in this subject		
Committed	37	61	2		
Withdrew	35	56	9	0.03	1

* means significance at 5% level of probability
** means significance at 1% level of probability

Thinking about your Physics course, tick the boxes below to reflect your opinions

	Strongly agree	Agree	Disagree	Strongly disagree
I found the course well organized	☐	☐	☐	☐
I felt the assessment methods used were good	☐	☐	☐	☐
The time demand was not reasonable for me	☐	☐	☐	☐
I found a good support from the academic staff	☐	☐	☐	☐
I think there will be poor career opportunities	☐	☐	☐	☐

Level 1: Committed and Withdrew

	Committed N=60	**Withdrew N=27**	χ^2
	%	%	
1. I found the course well organized			
agree	98	100	-
disagree	2	0	
2. I felt the assessment methods used were good			
agree	78	100	-
disagree	8	0	
3. The time demand was NOT reasonable for me			
agree	28	43	1.17
disagree	72	57	
4. I found a good support from the academic staff			
agree	75	83	0.62
disagree	25	17	
5. I think there will be poor career opportunities			
agree	15	17	0.05
disagree	85	83`	

Correlation analyses of students' entry grades in Physics and Mathematics with students' Physics exams performance:

Entry Grades	*Maths. Grades (n=200)*	*Physics Grades (n=200)*	*P1X - 97/98 (n=181)*	*P1Y- 97/98 (n=184)*	*P2X 98/99 (n=83)*	*P2Y 98/99 (n=83)*
Maths.	1	0.66**	0.04	0.35**	0.53**	0.29*
Physics	0.66**	1	0.01	0.27	0.21*	0.21*

"Committed students" (n=59)

Matriculation number	sex	Hr P	Hr M	entry points	degree	P1X	P1Y	P2X	P2Y
9702932	f	A	A	15	P	a	a	a	a
9704051	f	A	A	21	M	a	a	a	a
9702563	f	A	A	16	P	b	a	b	a
9704211	f	B	A	16	P	a	a	b	c
9704669	f	B	B	9	P	g	b	c	c
9704617	f	A	A	15	P+A	b	c	c	b
9704352	f	A	B	21	P+Mus	b	b	c	c
9704268	f	B	A	20	P+A	b	a	c	c
9702492	f	B	B	9	P	a	c	d	d
9703195	f	B	B	11	P+M	b	c	d	d
9609217	f	B	B	13	P+A	c	c	e	e
9703873	f	B	B	6	P+M	b	c	e	c
9704299	m	A	A	15	P+M	f	a	a	a
9704357	m	A	A	16	P+A	e	a	a	a
9704627	m	A	A	12	P	a	a	a	a
9703253	m	A	A	12	P	c	a	a	a
9705876	m	A	A	13	P+A	a	a	a	a
9703628	m	A	A	14	?	g	a	a	a
9703680	m	A	A	18	CP	g	a	a	a
9702890	m	A	B	11	P+A	a	a	a	a
9702906	m	A	A	11	BIOL?	a	a	a	a
9703033	m	A	A	15	P+A	b	a	a	a
9703092	m	B	B	8	P+EE	b	a	a	b
9704034	m	A	A	15	M	b	a	a	c
9702840	m	A	B	12	P+A	c	a	a	b
9704200	m	A	A	15	P+M	a	a	a	a
9607970	m	A	A	17	P	a	a	a	b
9705069	m	A	A	13	P	a	a	a	a
9704054	m	A	A	18	P	c	a	a	a
9703634	m	B	A	12	P	a	a	b	c
9704036	m	A	A	14	P+M	b	a	b	a
9706621	m	B	B	9	P+A		a	b	b
9704150	m	A	B	18	P	b	b	b	a
	m	A	A	14	CP	e	a	b	c
9703737	m	B	B	11	P+A	c	a	b	c
9702333	m	A	B	10	P	a	c	b	b
9703115	m	A	A	13	P+M	a	a	b	a
9705505	m	A	A	10	M	g	b	b	b
9703990	m	A	A	14	CP	a	a	b	c
9703019	m	A	A	18	P		b	b	c
9702276	m	A	A	14	CHEM	b	a	b	a
9705200	m	B	B	15	P	d	a	c	b
9704261	m	A	A	18	P+EE	a	a	c	d
9703368	m	A	A	14	P+M	a	a	c	wd
9704339	m	B	C	9	P+A	d	a	c	a
9700100	m	B	C	8	CP	b	d	c	d
9703550	m	A	B	18	CP	c	b	c	b
9702213	m	B	B	15	P+M	a	a	c	c
9706073	m	B	A	12	P	d	a	c	d

9703367	m	A	B	13	P+A	e	a	c	c
9703166	m	A	A	15	P	a	b	d	d
9702746	m	A	A	10	GEOG	b	b	d	d
9705698	m	A	B	9	P	b	b	d	c
	m	A	A	15	CP	a	b	d	f
9704242	m		B	12	P+A	e	b	d	d
9703165	m	B	B	6	A+M	d	c	e	e
9364171	m	A	B	6	P+A	a	c	e	c
9702555	m	A	A	15	P+PHIL	a	d	e	mv
9704096	m	A	B	12	CS	a	d	f	f

Note: P1X – Physics level 1 first term exams
P1Y – Physics level 1 second term exams
P2X – Physics level 2 first term exams
P2Y – Physics level 2 second term exams

"Withdrew students" (n=23)

Matriculation number	sex	Hr P	Hr M	entry points	degree	P1X	P1Y
9702453	f	A	A	18	P+Geol	c	a
9703322	f	A	B	17	P+M	a	c
9704083	f	B	B	10	P+A	a	
9705603	f	B	B	9	P+A	a	c
9700156	f	A	A	15	P+A	a	b
9703390	f	B	C	13	P		n
9703703	f	B	B	12	P	c	c
9704341	f	A	A	15	P	a	a
9704130	m	B	B	9	P+M	b	
9707627	m	B	A	8	P+M	b	c
9704380	m	B	B	12	P+A	b	
9706067	m	B	C	8	P+A	d	c
9703735	m	A	B	11	P+A	a	b
9703488	m	A	B	11	P+A	a	c
9704091	m	A	B	19	P?	a	b
9703305	m	B	B	7	P	f	d
9705250	m	C	C	8	P	c	g
9706029	m	C	C	6	P	a	d
9702744	m	B	C	7	P	c	e
9706482	m	C	C	6	P	a	e
9704260	m	B	B	8	P	f	g
9707621	m	B	D	7	P	b	d
	m	A	A	13	P	a	c

Note: P1X – Physics level 1 first term exams
P1Y – Physics level 1 second term exams

"General students" (n=28)

Matriculation number	sex	Hr P	Hr M	entry points	degree	P1X	P1Y
9702598	f	A	A	18	M	d	c
9702953	f	A	A	13	M	a	b
9703925	f	A	B	12	M	a	c
9704438	f	A	A	13	CS	e	a
9608013	f	A	A	15	CS		a
9704827	f	A	A	15	CHEM	c	b
9706066	m	A	A	18	M+CS	f	a
9703558	m	B	A	13	M	b	f
9706553	m	C	C	5	ESE	c	g
9703222	m	B	B	7	ESE	d	d
9706204	m	B	B	12	CS		d
9608231	m	A	B	14	CS	e	d
9706176	m	B	C	7	CS	f	g
9702914	m	A	A	15	CS	f	a
9702934	m	B	B	11	CS	b	a
9601349	m	A	B	11	CS	a	a
9703791	m	C	B	9	CS	c	n
9706905	m	B	B	8	CS	c	d
9703830	m	B	B	13	CS	d	b
9705274	m	A	B	16	CS	a	c
9704282	m	A	C	13	CS	c	b
9702965	m	A	A	17	CS	b	a
9705750	m	B	A	12	CS	a	b
9702655	m	B	A	10	CS	d	d
9703348	m	B	C	4	CS	c	e
9703941	m	A	A	12	CS	a	b
9702455	m	B	C	6	CHEM	c	f
9704095	m	A	B	10	BIOCHEM	b	

Note: P1X – Physics level 1 first term exams
P1Y – Physics level 1 second term exams

Appendix R

Report of the interviews with Physics students

Interview report

Interview took place from 4th till 18th May, 1999. The total number of students interviewed was 11. Eight students were from the level 1 Physics course (three girls out of that number) and three students from the level 2 Physics course. Those students who came to the interview were volunteers: in the questionnaire (level 1/ level 2 1998/99) there was an invitation to participate in further interview "*we would like to interview a group of students about your view of Physics laboratory practice* (level 1) */Physics course (*level 2*) next term. If you are willing to help, please leave your name)"*. Eleven students from the level 1 and four students from the level 2 had left their names.

The interview was held in a quite informal relax atmosphere (the students were offered tea/coffee, biscuits). Three students from the level 1 were interviewed simultaneously in a group, while the rest students were interviewed personally. The time for the interview was long: 30-60 min. All interviews were tape recorded.

Each interview followed the pattern:

1. Checking validity of responses to the student questionnaires by means of simple direct questions about:
   a) course of lectures (lectures boring/interesting);
   b) organization of the course (very good, good, bad, very bad);
   c) tutorials (tutorials helpful/tutorials waste of time);
   d) tutors/demonstrators (tutors/demonstrators helpful/unhelpful);
   e) assessment methods used (very good, good, bad, very bad);
   f) labs (interesting/boring);
   g) expectations from the Physics Department (fulfilled/not fulfilled)
   h) most exciting/ most disappointed experience.

2. Because from the previous analyses it was found that the most unpopular activity for the Physics 1st course students was the laboratory work [I am enjoying laboratory work (28% level 1; 41% level 2)/I hate laboratory work (27%level 1; 4% level 2); level 1 students were statistically different from the level 2 students and much more

negative that the last ones] the second part of the interview was devoted to an exploration of student views about laboratory work.

3. Third part of the Interview was devoted to the discussing of the idea of introducing the Pre- and Post-labs exercises in the laboratory practice. Exemplars were shown and there was discussion about practical way of implementation, with advantages and shortcomings highlighted.

We will further present the results for the total number of students interviewed (11), pointed where appropriate the differences between level 1 and level 2 student comments.

Results and comments are below:

Part 1

On the question "How are you doing?" the answers were very positive and optimistic. It let us assume that the students who came for an interview were fairly successful in their studies.

a) *course of lectures*; discussing the course of lectures students were fairly positive about it in general, also level 1 students did not find the course of lectures very interesting. Students comments about course of lectures were:
   - lectures were interesting (3 out of 11 students).
   - Optics lectures were very boring and poor presented (3 out of 8 level 1 students);
   - too much repetitions in the level 1 from school (e.g. course on Dynamics), on the level 2 from the level 1 course (2 students);
   - more demonstrations during the lectures (lectures are very dry) (2 students)

b) *organisation of the course;* all students from the both courses were fairly happy with the overall course organisation. Some remarks were done about the organisation of the laboratory practice and particularly its assessment, but this will be discussed in details below.

c) *tutorials;* in general tutorial were evaluated positively by students. Students comments:

- all right (enough tutorials, task are interesting and helpful to prepare for exams) (6 out of 11);
- more tutorials would be helpful (2 students from the level 1);
- 2nd course tutors are prepared better than the level 1 tutors) (1 level 2 student);
- questions should be better selected (1 level 1 student).

d) *tutors/demonstrators*; students' experience was different with different tutors and demonstrators: some of them were pleased with a demonstrator for one term and unhappy about another for other term. The common disappointments were about:

- demonstrator was not familiar with the experiment and unable to help (3 out of 8)
- tutor was not able to explain the theory well and can not meet students' questions (2 out of 11)

Most complains from the level 1 students were towards foreign postgraduate students who were not familiar with experiments very well and who speak English which they could not understand.

- "pleased about the way demonstrator help me, but unhappy about the way they mark my work" (5 out of 8 1st course students).

In drawing conclusions about tutors and demonstrator, we can say that students were happy about the way tutor/demonstrator help them on tutorials or during the laboratory as long as the demonstrator knows experiment himself/herself and the tutor knows the theory and way of performing the task.

The vast majority of students were really unhappy about the way how their laboratory records were marked *"too much depends from the mood of the demonstrator*!" Clear instructions should be given to demonstrators how to assess students laboratory performance and their records and some feedback should be given to students about their work.

e) ***assessment***; discussing the assessment method used for both courses we found out that the second course students were generally happy about the way their work is assessed - 60% exam+20% class test +20% laboratory. The majority of the first course students (5 out of 8) would like to have their class test performance to be marked.

f) ***laboratory***; all students pointed that the laboratory is an important activity in their Physics course. No one said that it is waste of time or a worse doing activity, but no one of them was happy about the university laboratory practice. The reasons were different: way of marking laboratory records, way of writing the report, set of experiments, longitudity of laboratory work.

The most interesting laboratories in the level 1 course were:

- spectrometer (3 out of 8)
- e/m (2 out of 8)
- thermal radiation (1 out of 8)

Two students could not say which lab was the most interesting. All were rather boring for them.

The most boring labs were:

- electronics (4 out of 8)
- e/m (2 out of 8)

g) the expectations from the Physics Department were pretty the same for the majority of students (7 out of 11). 2 students expressed disappointments about repetitions of the material they covered in their school physics course in the first term of the level 1 course and 2 students pointed that there were promised such courses as cosmology, astrophysics, quantum mechanics in the Department prospect but they did not meet these subjects in their level 1 Physic course (these two students were those who were planning degree in other subject(s), but not in Physics).

h) *the most exiting/disappointing experience in the Physics course*; 4 out of 8 level 1 students could not say what was the most exciting experience during their Physics course. The rest pointed the following activities:

- professor Saxon lectures/demonstrators (2 level 1 females);
- Quantum mechanics course of lectures (1 level 1 female);
- second term labs (1 level 1 male).

The most disappointing experience was:

- was not cosmology and astrophysics as promised (2 level 1 students);
- were too much repetitions from school and the first course (2 students);

- Optics lectures (2 level 1 students);
- course of lectures was too dry (1 level 1 student);
- labs (1 level 1 student);

the rest of the students (3 out 11) have no disappointments from the course.

Part 2

As was already described above, the second part of the interview was devoted to the consideration of the problems around the laboratory practice. The responses obtained from the students were the following:

a) one of the level 2 students comparing the level 1 laboratory with the level 2 one pointed how easy it was to perform the experiments during the first course; the instructions were so clear, so you should not think too much just follow what was said in the Manual and you will get the necessary data. The level 2 labs were totally different - there were very few instructions how to perform so you should really think and let your brain work hard to perform an experiment. There was a huge jump from the spoon-feed 1st course to the independent 2nd . Some arrangements should be introduced in the level 1 laboratory practice to prepare students to further more independent work in level 2. From the second term the level 1 course students are ready to perform more independently.

b) I would like to include here the answer of the level 1 student about his way of performing the experiments in the laboratory: "*during the experiment I have not too much idea about it. I am too busy collecting the data. I start thinking about the experiment only when writing the record.*" Practically the same description of work was given by another level 1 student.

c) two level 1 students said that the labs were really boring.

To generalise above we can conclude that the level 1 ***Manual*** provides students with very clear step-by-step instructions for performing experiments, but not too much information about Physics behind the experiment. However, as it was mentioned above, the real problem with laboratory for the most of students was related to the way of marking the laboratory records and reports. We have already discussed the problems around writing records and their assessment. We would like to discuss the problem with ***Reports*** below:

- only one student out of 11 said that the writing of Report is waste of time activity, all the others we quite positive about writing Reports. It was pointed that writing Report is good to practice the IT skills (7 students), look at the theory deeper (6 students)

But some improvements need to be done to make students happy about writing Reports;

1) there should be clear instructions how to mark the Report and students should have the feedback explaining their mark (practically all interviewed students have got the mark for their Report lower than they expected. Most of them think that the main reason for that was - the Report was not long enough. They were going to make their second Report longer);
2) there is not good idea to write the Report on the base of the marked Record. Students would like to have a choice in choosing experiments they would like to look at the theory deeper ("pick whatever experiment you want to do").
3) there should be an opportunity to see the example of the report as well as the record, to have an idea what is expected from you and how this can be done.

In summary for these two parts of the interview we would like to include the suggestions of students how to make the Physics course better:

a) make course as blocks of lectures (like in Chemistry). It is not a good idea to have different lectures during the one week and jump from one course to another;
b) make the term 1 of the level 1 Physics course more interesting (term 2 of the 1st course is much more interesting);
c) more demonstrations on the lectures;
d) Class Test should be given a credit;
e) instructions should be given to demonstrators how to mark the records/reports.
f) working examples how to write records/reports;
g) make the instructions for the term 2 of the level 1 laboratory practice not so detailed; teach students how to think and perform the experiments rather than follow the instructions.

Part 3

The third part of the interview was devoted to the idea of Pre- and Post- Labs exercises in laboratory practice.

1) PRE-LAB

An example of a pre-lab exercise was presented (relating to the Spectrometer experiment). The idea of the pre-lab as the theoretical preparation to the experiment which involves the home work according to the given instructions was explained to the students. All students were given time to be introduced to the pre-lab. They were very positive about this specific pre-lab as well as the whole idea of pre-lab exercises. Every student's comments were very positive. [For some students doing Chemical Physics this idea is not new at all and they were very enthusiastic about it. "*It makes experiment much easier and much quicker to perform*"].

2) TEST

To check students' preparation to the laboratory we proposed to introduce the test, which students should perform before the laboratory and which should be marked by the demonstrator. The mark for the test will be included to the total mark for the laboratory performance. Students' reactions were varied:

- excellent idea to check the preparation have a quick feedback about it;
- not happy about the test, probably discussion with the demonstrator is better;
- test up to you, but it should not be marked in any case.
- it is all right (5 students)
- good idea (3 students)

3) POST-LAB

The idea of post-lab exercises was introduced and exemplars shown. The aim of the post-lab was to allow students to apply what they learned from the experiment, often in a novel and applied context. All students were very, very positive about the idea of post-lab. The words of one student about post-lab summarise the opinions of all interviewed students: "*really-really good idea. It makes sense of experiment, useful to set up the theory. I do not think anybody in the course will object!*".

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Appendix S

Science-related persuasive message and intervention in a class-room (guidance and recommendations)

A summary of how to construct a science-specific persuasive message and how to conduct an intervention in a classroom.

The Model of Planned Behaviour was found to be a useful tool in explaining and predicting pupils' science-related behaviour (see Chapter 3). This Model explains how different kind of beliefs may influence pupils' behaviour. Information about personal beliefs that determine the attitudes towards behaviour, for example "*enrolling in Physics next academic year*", can be investigated and used to develop systematically planned interventions to deliver a science-specific persuasive message addressed to students' instrumental beliefs about engaging in Physics. Such kind of intervention should be helpful in providing students with additional information to help them to make their decisions.

Persuasion research in science education is a direct outgrowth of the work done by Hovland and his colleges (1953) who were the first researchers who systematically investigate the effectiveness of persuasive message on attitude change. The basic assumptions that supported their work are:

a) learning new information from a persuasive message will change beliefs, the cognitive basis of attitudes;
b) remembering the information will provide the persistence of attitude change.

According to these assumptions, a persuasive message will be effective to the extend it is attended to, comprehended, and accepted.

Experimental studies of attitude-behaviour relationships in science education mostly draw upon the works of Fishbein and Ajzen (1980), Ajzen (1985), Petty and Cacioppo (1986). Shrigley (1976) was the first who used the results of these studies to investigate science-related attitude change. These initial efforts resulted in the development of a model for constructing science-specific persuasive messages (Crawley and Koballa, 1994) and conducting intervention programs.

The following information should be helpful in providing with some practical guidance and advises about how to create a science-specific persuasive message and how to conduct an intervention program in a classroom.

1) Specifying the target behaviour

Ajzen &Fishbein (1977) noted that behaviour can be viewed as consisting of four elements. The first element is the *action* performed; e.g. behaviour of learning, doing, constructing. The second element is the *target* at which the action is directed, e.g. action was directed at a Physics, experiment. The third element is the *context* in which the action is performed; e.g. the action was performed in the University, in the laboratory, at school. Finally, every behaviour has a *time* component; e.g. action was performed in academic year1998/99, in the first term, before Christmas. By putting these components together the complete behaviour is specified. For example, the behaviour "To enroll (action) in a school (context) Physics course (target) in academic year 1998/99 (time)" contains four behavioural elements. According to Ajzen and Fishbein (1977), in order to predict a behaviour from knowledge of attitudes the attitude measure employed should correspond to the behaviour on the action, context, and target and time categories. If there is no correspondence, a significant relationship between attitudes and behaviours will usually not be obtained.

2) Determining the salient beliefs of the target group.

People can hold a great number of beliefs about personal consequences, social support, self-efficacy related to engagement in a specific behaviour, but it is believed that they can attend to only a small number of them (six plus/minus two) at any given time (Johnstone, 1984). These key beliefs related to the specified behaviour are called *salient beliefs*. The guidelines about how to identify the salient beliefs are given by Ajzen and Fishbein (1980, p.261). This can be done by means of an open-ended questionnaire, which must contain questions to identify the personal beliefs, salient referents and control beliefs that can be important determinants of personal intention to engage in the target behaviour (according to the Theory of Planned Behaviour). For example:

1. to obtain a student's salient beliefs about the enrolling in school Physics course next academic 1998/99 year a student should specify advantages/disadvantages of his "*enrolling in school Physics course in 1998/99*";
2. salient beliefs about the social support for engaging in the target behaviour can be obtained by asking a student to specify the group of people who may approve/disapprove his "enrolling in school Physics course in 1998/99);
3. salient beliefs about the factors that may facilitate or obstruct the engaging in the target behaviour can be obtained by asking a student to specify the factors that would make it easy/difficult for him to enroll in Physics course next year.

Information obtained from such an open-ended questionnaire will provide a researcher with salient beliefs (personal, normative and control beliefs) that pupil have about engaging in Physics. Those beliefs that appeared in 90% of responses can be considered as *modal salient beliefs.*

Analyses of these beliefs will provide a researcher with a picture of factors which can facilitate or prevent students' intentions towards studying Physics. Message addressed to these beliefs should be useful in providing students with some new information relating to their beliefs and, what is particularly important to correct the basis for beliefs which were formed on the base of misconceptions or wrong stereotypes.

There is some information about factors which may facilitate the intervention program:

Development of a persuasive message

Several message factors were found to play a role in the persuasive efficiency of the persuasive message. These factors were derived from the research done in psychology regarding persuasion and it is worth taking these factors in to account while constructing a science-related persuasive message.

1) *message comprehensibility* - for message to be persuasive it must be first attended to and comprehended (Hovland *et al., 1957);*

2) *number of arguments* - more arguments are not always better. There is some evidence that increasing the number of high quality arguments does increase the attitude change while increasing the number of low quality arguments can decrease the extent of attitude change. Quantity is also related to the subject's perception of the argument's validity. People may stop attending to the message if it goes on and on. People can think about and remember only a limited amount of information during a given time interval. Providing a person with a few very convincing arguments may promote more attitude change than providing these arguments along with a number of much weaker arguments (Anderson, 1974);
3) *one-sided or two-sided messages* - if an audience has some knowledge about the issue or object under consideration and/or initially opposed their advocacy, then a two-sided rather than one-sided message will be more persuasive; if an audience knew very little about the issue and/or initially agreed with its advocacy one-sided communications were found to be more effective in persuasion. (Hovland *et al.*, 1957);
4) *conclusion-drawing* - a conclusion is usually helpful for the audience to understand and remember the message of the arguments and their advocacy (Hovland & Mandel, 1952). Further research has demonstrated that self-generated information is more persuasive than information generated externally (Lindel and Worchel, 1970);
5) *counter - or proattitudinal position* - subject generates more issue-relevant thoughts when the arguments were used to support the counter - rather than proattitudinal position (Chaiken and Eagly, 1993);
6) *message repetition* - number of repetitions (up to 3) lead to better learning and retention of arguments in the message. Continued presentations of a persuasive message may maintain retention at a high level, but can decrease attitude change (Cacioppo and Petty, 1979).

Conducting the intervention program

The view that persuasion cannot occur unless the recipient actively participates in the process suggests that factors other than the message itself should be considered in structuring a persuasive intervention. This is totally relevant regarding conducting an intervention program in Education.

Researches confirmed that such factors as

a) source of persuasive communication;
b) recipient factors;
c) channel factors

must be taken in to account while conducting the intervention.

a) Source factors

The source of the persuasive message is very important since people sometimes accept or reject an advocacy immediately following its presentation on the basis of source cues rather than on the basis of the content of the message. This is especially likely to occur when a) the source clearly possesses either high or low credibility so that the recipient need not carefully attend to know how to react on advocacy (Mills and Harvey, 1972) and b) the communication pertains to the issue that is not personally relevant or significant to recipient so there is a little reason to devote much attention to the message (Craig and McCann, 1978).

Other *source factors* influencing on persuasion can be the following:

- *communicator credibility* - research on communicator characteristics suggests that a source perceived by the audience as credible - both *knowledgeable* and *trustworthy,* - will enhance persuasion. "Correct" attitude was associated with rewards in the past. An expert (credible source) is supposed to be more knowledgeable (and more often right) and accepting his position will likely lead to "reward" (Norman, 1976);

- *persuasive intent of the message* - a source who has persuasive intent is presumed to be less trustworthy than one who simply wants to communicate some message to the audience. A persuasive intent also appears to reduce the persuasion by motivating the recipient to couterargue the message while listening to it (Hass and Grady, 1975);

• *physical attractiveness of the source* - physically attractive communicators were found to be more persuasive among students than unattractive communicators, as revealed both by the verbal and behavioural measure (Chaiken, 1979);

• *communicator power* -Kelman (1958) suggested that people express more public agreement to a powerful communicator than to a weak communicator. A powerful communicator means a source that can administer rewards or punishment to the recipient.

b) Recipient factors

A recipient factor was recognized to be important in a persuasion. Several studies were devoted to search for "persuasibility" among people. Some generalisation driven from this work is given below:

• *intelligence* - some studies of intelligence and persuasibility indicate that people with high intelligence are less persuadable than those with normal to low intelligence (McGuire, 1969). A child is increasingly persuadable until around age of eight, after which time the child becomes less persuadable each year until some stable level of persuasibility is reached (Petty and Cacioppo, 1981, pg.80);

• *sex difference* - observed in most investigations (women were easier persuade than men, (Eagly, 1978)). However, when men were less familiar with the issue than women men were easier to persuade. Under the low personal consequence conditions, women agreed more with the options of others than men did. It appears that the female role to be cooperative and the male role to be independent is most likely to affect the extent of influence when the personal consequences of agreement are low. When the consequences of agreement are increased, the extent of the influence is determined more by the person's ability to process the issue- relevant information presented than by his gender (Eagly, 1978).

c) Channel factors

There are several possible ways to communicate to deliver the persuasive message. This can be done by distributing the written text (print communication), or present the message personally (personal communication), or record the message and let the audience to listen it (audio communication), or record the message on video (video communication). The outcomes of the persuasive intervention very often affects how this communication was conducted (Hovland *et al.*, 1957)

- *face-to face communication* - generally has more impact than media communications (Katz and Lazarsfeld, 1955);
- *written communication* - when the input is complex, the written form brings about more attitude change than audio or video form (Chaiken and Eagly, 1976);
- *video, audio forms* - when the input is easy, the video produced greatest attitude change, the audio a bit less and written less again (Chaiken & Eagly, 1976; Eagly 1974).

Appendix T

Pre-labs and post-labs exercises for the university Physics laboratory practice

PRE-LAB: SPECTROMETER

This pre-lab is intended to help you obtain a better understanding of the experiment before doing it in the laboratory. If you are familiar with the experiment before you come to the laboratory you will need less time to perform your experimental tasks. If you understand the theory behind the experiment there will be more time for you to think about the experiment and processes related to it while working in the laboratory.

What will I be doing in this lab?
You will be working with a prism spectrometer to do some measurements to investigate the radiation spectra of Helium, Mercury and Hydrogen.

What will this laboratory work teach me about?
Doing this laboratory practice you will learn:
- what a prism spectrometer is;
- what properties of a prism allow us to use it for spectrum measurements;
- how to set up a prism spectrometer and how to use it to measure a spectrum of an element.

What new skills can I expect to obtain from this lab?
- practical skills in working with a prism spectrometer and an appreciation of its advantages and shortcomings;
- knowledge and skill in setting up and identifying the atomic spectra and an appreciation of the role of spectral analyses in the identification of elements;
- better understanding of the Law of Refraction and its practical applications.

To which part of my Physics course does this lab belong?
This lab covers material from two sections in your first year course;
- quantum phenomena (atomic structure, emission of electromagnetic radiation by atoms, atomic line spectra and energy levels);
- Optics, namely Geometric Optics (refraction of light, Laws of Refraction, dispersion, disperse power of a prism).

What should I know before I begin the lab?

1. Before coming to the laboratory make sure you know the meaning of the following concepts (*your knowledge of them will be checked using a brief test)*

   Radiation, spectrum, frequency and energy of radiation, spectrometer, prism spectrometer, index of refraction, dispersion, dispersive power of a prism.

2. Have a sketch of a prism spectrometer in your laboratory book ready.

Self-assessment questions:

(*By answering the questions below you will check that you have the necessary theory to perform the experiment in the laboratory and so demonstrate that you are ready for the* *lab. Similar questions will be used in the test. If you have difficulty in answering these questions go to the prescribed sections from the textbook (Young and Freedman, 9th edition) or refer to your lecture notes)*

What is radiation? (p.1236)

What is meant by a spectrum? (pp. 1229, 1236-1238)

What information about atomic structure can be obtained from a spectrum? (pp.1229-1230)

How long can an atom exist in its a) ground state; b) exited state? (pp. 1239-1240)

Why is it possible to identify an atom using its spectrum? (p. 1230)

What is the index of refraction? (pp. 1055-1056)

What is dispersion? (pp. 1063-1064)

What is the relationship between the speed of light in a vacuum and in a medium? (pp. 1055-1056)

What is a dispersive power of a prism? (pp.1057-1059)

SPECTROMETER

Pre-lab multiple response test

Name ______________________**Matriculation number**_________________

In answering this multiple response test you can select *none*, *some* *or* *all* *of the choices as right answers. Your choice(s) should be marked by shading in the boxes next to them.* .

1. What is a ***spectrum***?
   - ■ a set of lines arranged in a special order
   - ☐ a set of atomic energy levels
   - ■ a set of frequencies of electromagnetic radiation radiated by any atom
   - ■ a set of energies equal to energy differences between atomic energy levels
   - ☐ the intensity of radiation

2. Which information about an atom can you obtain from its spectrum?
   - ☐ the energy of its atomic levels
   - ■ the name of an atom
   - ■ the distribution of its energy levels
   - ☐ the number of energy levels in the atom
   - ☐ the internal structure of the atom
   - ■ the set of energy differences between the atomic levels

3. What is *radiation?*
   - ☐ the amount of energy added to an atom causing excitation of the atom
   - ■ the energy released from an atom during a transition from a higher to lower energy state
   - ■ a light quantum of energy equal to the energy difference between any two atomic levels
   - ■ an electromagnetic wave of a certain energy emitted by an atom
   - ☐ intrinsic characteristics of an atom

4. Why is it possible to identify an atom using its spectrum?
   - ■ each atom has a different number of electrons and hence a unique set of energy levels
   - ■ all isolated atoms of a given element have the same set of energy levels
   - ■ the distribution of energy levels is unique for any chemical element
   - ☐ a spectrum provides a unique opportunity to look inside an atom

5. What do we measure by a *prism spectrometer*?
   - ☐ the frequency of light
   - ☐ the wavelength of light
   - ■ the angle of refraction of light by a prism
   - ☐ the dispersive power of a prism

- ☐ the index of refraction of light

6. What does the index of refraction of a medium tell us about?
   - ■ the velocity of light inside a medium
   - ☐ the angle of deviation of light from its initial direction while passing through a medium
   - ■ the influence of a medium on light propagation inside the medium
   - ■ the ratio of light velocity in a vacuum to light velocity in a medium
   - ☐ the wavelength of light in a medium
   - ■ index of refraction for a violet light is always greater than index of refraction for red light for most transparent materials

7. What is dispersion?
   - ☐ it is a characteristic of a prism
   - ☐ the difference between light velocity in a medium to light velocity in a vacuum
   - ■ the dependence of the index of refraction of light on its wavelength
   - ■ the dependence of the angle of refraction of light on its wavelength

8. What does *dispersive power of a prism* mean?
   - ☐ the ability of a prism to transmit only a high energy radiation
   - ☐ the ability of a prism to reflect totaly light incident on it
   - ■ the ability of a prism to refract different wavelengths at different angles
   - ☐ the ability of a prism to mix different wavelength together in different combinations

9. How does the energy of radiation depend on frequency of radiation?
   - ☐ there is no connection between them in a vacuum
   - ■ the energy of radiation is proportional to the frequency of radiation
   - ■ the higher the frequency of radiation the more energy it carries
   - ■ red light carries less energy than violet light

10. In which of the following devices a prism is used?
    - ☐ in a telescope
    - ☐ in a microscope
    - ■ in a periscope
    - ■ in a prism spectrometer

POST-LAB

Name______________________ **Matriculation number**_______________

The aim of the post-lab is to help you to extend the knowledge obtained during your laboratory practice and to consolidate it by solving some real-life problems. Your answers will be checked and your performance will be discussed with you by your demonstrator.

SPECTROMETER

1. When an electric current is passed through certain gases they glow with characteristic colors, e.g. red for neon and orange for sodium. Because of such qualities they are widely used in advertising. In terms of atomic structure, what do you think is happening to produce the light from those gases?

2. You know that violet light is dangerous for your eyes: looking at it can damage your retina and cause serious problems with sight. However day-light is much safer. Can you explain why?

3. All road signs are made of a special material. If you look at them in the dark you cannot read anything on them, but as soon as the light from your headlight falls on them they become very bright and you can easily read everything. Applying your knowledge about atomic structure try to explain this property of road signs at night.

4. After rain many of us enjoy the magnificent view of a rainbow. Why does this phenomenon take place after rain?

5. What is your favorite precious stone? Many people prefer diamond. This stone is not only one of the most beautiful stones it is also one of the hardest minerals in nature. When you look at a diamond it seems to change its color as you move it and you cannot say exactly what color is dominant. How can you explain this quality of diamond giving rise to its beauty?

PRE-LAB: ACCELERATED MOTION

This pre-lab is intended to help you obtain a better understanding of the experiment before doing it in the laboratory. If you are familiar with the experiment before you come to the laboratory you will need less time to perform your experimental tasks. If you understand the theory behind the experiment there will be more time for you to think about the experiment and processes related to it while working in the laboratory.

What will I be doing in this lab?

You will investigate two types of *accelerated* motion

a) free -fall accelerated motion (motion with a constant acceleration),

b) simple harmonic motion (motion with a non-constant acceleration)

and use their laws to obtain the constant of acceleration due to gravity "g".

What will this laboratory work teach me about?

Doing this laboratory practice you will learn:

- that free-fall motion and simple harmonic motion (SHM) are two different types of accelerated motion;
- about forces causing these two types of motion: free fall acceleration is caused by the force of gravity and SHM is caused by the restoring force;
- that the acceleration due to gravity is a constant and its value can be estimated e.g. by: 1) using the law of free-fall accelerated motion and 2) using the law of SHM.

What new skills and knowledge can I expect to obtain from this lab?

- better understanding of different kind of accelerated motions and conditions under which they take place;
- skills in measuring the constant of acceleration due to gravity by two different methods;
- practical application of the laws of SHM to evaluate the period of a swinging pendulum and period of spring-mass oscillations;
- understanding the conditions under which a swinging pendulum will not obey the law of a simple harmonic motion.

To which part of my Physics course does this lab belong?

This lab belongs to the section of your course called "Dynamics and relativity" and covers the following material;

- motion in one dimension; uniformly accelerated motion;
- simple harmonic motion; displacement, velocity, acceleration, frequency, period, angular frequency in SHM.

What should I know before I begin the lab?

Before coming to the laboratory make sure you know the meaning of the following concepts (*your knowledge of them will be checked using a brief test)*

> *Velocity, acceleration, equation of free-fall accelerated motion, equation of SHM, restoring force, Hooks Law, period, period of pendulum swinging, period of spring-mass oscillations, value for the constant of acceleration due to gravity g.*

Self-assessment questions:

(By answering the questions below you will check that you have the necessary theory to perform the experiment in the laboratory and so demonstrate that you are ready for the lab. Similar questions will be used in the test. If you have difficulty in answering these questions go to the prescribed sections from the textbook (Young and Freedman, 9th edition) or refer to your lecture notes)

How do coordinate, velocity and acceleration vary with time for a particle moving with *constant* acceleration? *(pp. 37, 41-42)*

What is free-fall acceleration? What is the numerical value of this acceleration and what are its unit? *(p. 46)*

What kind of motion do we call simple harmonic motion (SHM)? Give some examples of SHM. *(pp. 392-394)*

What is the magnitude and sign of the restoring force acting on a spring mass? *(p. 394)*

What is the equation for coordinate, velocity and acceleration with time in SHM? *(pp. 396-398)*

x(t) =

u(t) =

a(t) =

What kind of graph do we expect for coordinate versus of time in a) SHM; b) free-fall motion?

How do we define the period of spring-mass oscillations and period of swinging pendulum? *(pp. 396, 407-408)*

What is the necessary condition for a swinging pendulum to have a SHM? *(p. 408)*

ACCELERATED MOTION

Pre-lab multiple response test

Name ____________________ **Matriculation number**___________

In answering this multiple response test you can select none, some or all of the choices as right answers. Your choice(s) should be marked by shading in the boxes next to them.

1. Accelerated motion takes place when:
   - [x] a moving body suddenly changes its trajectory
   - [x] the trajectory of a moving body is not a straight line
   - [x] an outside force is applied to the body
   - [ ] no forces act on the body
   - [ ] friction is neglected

2. What is free-fall acceleration?
   - [ ] accelerated motion which any moving body has
   - [x] acceleration which takes place under the influence of gravity
   - [x] acceleration which is the same for any body falling in a vacuum
   - [x] acceleration which takes place when only the force of gravity is considered and all the other forces are neglected
   - [ ] acceleration which is equal to 9.81 m/sec for any body of any weight, size and shape falling in any medium

3. Which of the following are examples of motion with *constant* acceleration?
   - [x] motion of the moon round the earth
   - [x] motion of the earth round the sun
   - [x] motion of an apple falling from a tree
   - [ ] the vertical motion of a spring-mass combination
   - [ ] a pendulum swinging in an upright clock
   - [ ] the motion of water affected by tide

4. Simple harmonic motion is an example of:
   - [x] accelerated motion
   - [x] periodic motion
   - [ ] the simplest type of motion
   - [x] an idealistic type of motion, not found in nature
   - [ ] an effect due to the force of gravity
   - [x] motion due to a restoring force, only

5. Hook's law tells us about:
   - [ ] how any body is moving
   - [ ] the nature of the force of gravity
   - [x] the nature of the restoring force
   - [x] that acceleration is directly proportional to displacement
   - [x] that the restoring force acts opposite to displacement from equilibrium

6. What is *amplitude* in SHM?
   - [x] it is the maximum extension of a spring
   - [x] it is the maximum displacement of a pendulum-bob from equilibrium
   - [ ] it is the initial displacement of a body from equilibrium
   - [x] it is a physical characteristic of SHM

7. What kind of force do we consider as a *restoring* force?
   - [ ] a force giving a body a constant acceleration
   - [ ] a force varying periodically with time
   - [x] a force which causes a body to move round its equilibrium point
   - [x] a force which always acts opposite to displacement

8. How do the periods of a pendulum and a spring-mass combination depend on amplitude in SHM?
   - [ ] the larger the amplitude of a simple pendulum the larger is its period
   - [ ] the larger the amplitude of a spring-mass combination the shorter is its period
   - [x] the period of a simple pendulum is independent of amplitude
   - [x] the period of a spring-mass oscillations is the same for any amplitude and initial deviation from equilibrium
   - [ ] the period of a simple pendulum is proportional to amplitude

9. When can the motion of a simple pendulum be considered as SHM?
   - [x] if the acceleration of the pendulum is directly proportional to its displacement
   - [x] if the pendulum is swinging round its point of a stable equilibrium
   - [ ] swinging of a simple pendulum is always an example of SHM
   - [ ] if the applied force to the pendulum varies periodically with time
   - [x] if the initial displacement from equilibrium is small
   - [x] if period of the pendulum swinging is independent of its amplitude

10. How does acceleration vary in free-fall motion and in SHM motion?
   - [ ] acceleration in SHM varies periodically with time
   - [ ] acceleration in SHM is constant
   - [x] acceleration in free-fall motion is constant
   - [x] acceleration in SHM is proportional to displacement
   - [ ] acceleration in free-fall motion depends on a body mass

POST-LAB

Name______________________ **Matriculation number**______________

The aim of the post-lab is to help you to extend the knowledge obtained during your laboratory practice and to consolidate it by solving some real-life problems. Your answers will be checked and your performance will be discussed with you by your demonstrator.

ACCELERATED MOTION

1. Imagine two balls of the same volume, but different density and hence different mass, falling downward in air. What can you say about their free-fall acceleration? Will the situation be changed if these two balls have the same mass, but different volumes? Will the situation be changed if we consider balls falling in a vacuum?

2. Suggest an experiment to confirm that pendulum motion or the motion of a mass on a spring are examples of SHM.

3. Which car will undergo fewer oscillations on its spring suspension: the one with one passenger or the one with five? Confirm your answer.

4. You already know that by using a simple pendulum you can determine the acceleration due to gravity g. The same pendulum can be used by a geologist to find mineral deposits. Can you explain how this is possible and why?

5. Suggest a method to measure the height of any building in a few seconds without using any rulers or tape measures. Use a technique related to your lab work.

6. Consider a tunnel made through the Earth from one pole to another. What do you think would happen to you if you fell down such a tunnel? Of course, you will not hurt anything, because there is no bottom in such a tunnel. However, will you ever stop and why?

PRE-LAB: OPTICS

This pre-lab is intended to help you obtain a better understanding of the experiment before doing it in the laboratory. If you are familiar with the experiment before you come to the laboratory you will need less time to perform your experimental tasks. If you understand the theory behind the experiment there will be more time for you to think about the experiment and processes related to it while working in the laboratory.

What will I be doing in this lab?

In this lab you will study how the image of an object can be formed by different mirrors (*plane, concave and convex*) and lenses (*converging and diverging*).

What will this laboratory teach me about?

Doing this laboratory practice you will learn about the laws and rules of Geometrical Optics and their practical application, namely:

- how to use the mirror (lens) equation to obtain the position of the image of an object formed by mirrors or lenses;
- what are the ray diagrams and how to use them to locate the image of different objects formed by mirrors and lenses;
- how *real* and *virtual* images are formed and how to locate them.
- what are the differences between reflective objects (mirrors) and refractive objects (lenses);

What new skills can I expect to obtain from this lab?

- practical skills in using ray diagrams to locate the image of an object formed by spherical mirrors or lenses;
- practical skills in measuring object distance, image distance, focus distance of mirrors and lens;
- practical application of the Law of Reflection and the Law of Refraction;
- understanding of the underlying principles and function of some optical devices construction, like slide projectors, enlarging cameras, magnifying glass, telescope and microscope.

To which part from my Physics course does this lab belong?

This lab belongs to the part of your course called "Optics, Waves and Lasers" and covers the whole section of the course called "Geometrical Optics"

- reflection from plane and spherical surfaces, Law of reflection; position and location of images produced by reflection;
- refraction of light, Law of Refraction; image formation by thin lenses, its position and location.

What shall I know before I begin the lab?

Before coming to the laboratory make sure you know the meaning of the following concepts (*your knowledge of them will be checked using a brief test):*

Plane mirror, concave mirror, convex mirror, converging lens, diverging lens, focus, radius curvature, vertex of a mirror, optical axis, object, image, real image, virtual image, lens (mirror) equation, ray diagram, principal rays.

And be able to perform the following exercises:

1. Sketch a diagram showing the location of an image formed by a *concave mirror* of an object placed far away (at infinity) from the mirror.
2. Place an object at the focal point of a *converging lens*. Sketch a diagram showing where the image of the object will be formed. What is the distance from the lens to the image?
3. Draw the ray diagram showing the side where the image of an object formed by a *diverging lens* will always be located. Explain the result using a lens equation.

Self-assessment questions:

(By answering the questions below you will check that you have the necessary theory to perform the experiment in the laboratory and so demonstrate that you are ready for the lab. Similar questions will be used in the test. If you have difficulty in answering these questions go to the prescribed sections from the textbook (Young and Freedman, 9th edition) or refer to your lecture notes)

Law of Reflection and Law of Refraction. (pp. 1055-1057)

What is "Ray diagram" and when we can apply it? (p. 1095)

What is the concept of an "object", "image" and focal length (focus) in Optics? (pp. 1086-1087, 1091, 1095)

Mirror equation and lens equation. How focus, object and image are linked together? (p. 1091, 1104)

What are the Principal rays for mirrors and lenses? (pp. 1105-1107, pp. 1095-1097)

What are Real and Virtual sides for lenses and mirrors? (p. 1087)

What is the difference between plane and spherical mirrors? (pp. 1086-1090)

What is the difference between converging and diverging lenses? (pp.1101-1103)

OPTICS

Pre-lab multiple response test

Name ________________________**Matriculation number**________________

In answering this multiple response test you can select none, some or all of the choices as right answers. Your choice(s) should be marked by shading in the boxes next to them.

1. What is a *ray diagram*?
   - ☐ a set of waves of special behaviour
   - ■ a theoretical representation of light-wave propagation
   - ☐ a set of geometrical and trigonometrical rules
   - ■ a visual representation of how a light-wave front propagates

2. The *mirror equation* describes:
   - ☐ how light rays propagate
   - ☐ how light rays interact with the mirrow
   - ■ what kind of image can be formed by a mirror
   - ☐ what is the focal length of a mirror
   - ■ how the object, image and focal length of a mirror are connected

3. The lens equation describes:
   - ☐ how light rays propagate
   - ☐ how light rays interact with the lens
   - ■ what kind of image is formed by a lens
   - ■ how the object, image and focal length of a lens are connected

4. How does the focal length of a simple spherical mirror depend on its radius of curvature?
   - ■ the focal length of a mirror is proportional to its radius of curvature
   - ☐ the focal length of a mirror is equal to its radius of curvature
   - ■ the greater the radius of curvature the greated the focal length of a mirror
   - ■ the focal length of a mirror is half the radius of curvature

5. Why do we not use the Principal Rays for a plane mirror?
   - ☐ because a plane mirror reflects all rays falling on it
   - ■ because you can not build the focal point for a plane mirror
   - ■ because its has an infinite radius of curvature
   - ☐ because Principal Rays do not exist for a plane mirror

6. The *Law of Reflection* says that:

- ☐ all materials can not only transfer, but also reflect light falling on them
- ■ the *angle of incidentce* is the angle formed by the incident ray and the normal to surface
- ■ the reflected and the incident rays and the normal all lie in the same plane for any boundary
- ■ the angle of reflection is equal to the angle of incidence for all wavelength and for any material

7. The *Law of Refraction* says that:

- ☐ all materials can not only reflect, but also refract (transfer) light falling on them
- ■ the larger the index of refraction of the material the smaler is the angle of refraction
- ■ the ratio of the sine of the incident angle to the sine of the refracted angle is always equal to the inverse ratio of the two indexes of refraction
- ☐ the velocity of light inside any medium is the same as velocity of light in a vacuum
- ■ the incident ray and refracted ray always lie in the same plane

8. What kind of image can be formed by a *plane mirror, convex mirror and diverging lens?*

- ☐ only real
- ■ only imagine
- ☐ both real and imagine
- ☐ none of them

9. What kind of image can be formed by a *converging lens* and *concave mirror*?

- ☐ only real
- ☐ only imagine
- ■ both real and imagine
- ☐ none of them

10. The image for an object at infinity for a *converging lens* is found at:

- ☐ infinity
- ☐ the point of the radius of curvature of the lens
- ■ the focal point of the lens
- ☐ does not exist

11. The image for an object at infinity for a *concave mirror* is found at:

- ☐ infinity
- ☐ the point of the radius of curvature of the lens
- ■ the focal point of the lens
- ☐ does not exist

POST-LAB

Name______________________ **Matriculation number**________________

The aim of the post-lab is to help you to extend the knowledge obtained during your laboratory practice and to consolidate it by solving some real-life problems. Your answers will be checked and your performance will be discussed with you by your demonstrator.

OPTICS

1. Imagine that you are at an out-door concert enjoying both the music and action on the stage. Suddenly somebody taller than you stands up in front of you. You can still hear the music, but you cannot see the action on the stage any more. Both sound and light are wave phenomena. How then do you explain why you can still hear the sound but the light is blocked?

2. What kind of mirror will act as a rear-view mirror for a driver to give the best all-round view? *Ray diagram:*

3. How tall must a vertical mirror be to allow you to see your own full image in it?

4. Ladies often use small make-up mirrors, which enlarge the image slightly, but only show part of the face. Men use the same kind of mirror for shaving. What kind of mirror behaves in this way? Explain your answer using a rays diagram.

Ray diagram:

5. What kind of lens is used in enlarging cameras or slide projectors? Illustrate your answer using ray diagrams.

Ray diagram:

6. Copying cameras are used to copy pictures or documents. At what distance from the lens should we place the object to obtain an **exact** copy of it?

Ray diagram:

7. In the painting by Diego Velazquez (1599-1660) "The Toilet of Venus ("The Rokeby Venus") we can see Venus's face reflected in a mirror, held by an angel (see picture below). If we can see Venus face in the mirror, can she also see her reflection?