SCOTTISH SCHOOL LEAVERS' SURVEY SPECIAL STUDY

# PARTICIPATION IN SCIENCE, ENGINEERING AND TECHNOLOGY AT SCHOOL AND IN HIGHER EDUCATION

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**31 MAY 2002**

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Report to Scottish Executive Enterprise and
Lifelong Learning Department

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# CHAPTER 1: INTRODUCTION

The Scottish Executive has recently introduced a *Science Strategy for Scotland* to provide a framework for the development of policy for the support and use of science (Scottish Executive, 2001b). Science education is an important part of the science strategy, and accounts for the greatest proportion of the Executive's total science expenditure. A key aim of the strategy is to *"ensure that enough people study science to a standard which will enable the future needs of the country to be met"* (*op. cit.* section 3).

This report describes factors influencing participation in science, engineering and technology (SET) as young people make the transition from school to higher education in Scotland. It focuses on the cohort of young people who completed the final stage of compulsory schooling in 1998, and follows the progress of those who moved from school to higher education by 2001.

It forms the sixth of a series of reports commissioned by the Scottish Executive based on secondary analyses of the Scottish School Leavers Survey (SSLS). The SSLS is a postal-questionnaire survey and asks young people in Scotland about their experiences at school and transitions from school to post-compulsory education, training or work. The survey is described in more detail in Appendix 1. It is a general-purpose survey, and therefore does not gather detailed information about young peoples' decisions and choices with regard to subjects, courses and careers. For this study detailed information about their curriculum, courses, qualifications and attainment at school has been derived from data provided by the Scottish Qualifications Authority (SQA). The SSLS does not include information about teaching styles and teacher effectiveness or aspects of the labour market, that may influence participation in science.

Other reports in the series have focused on:

- Entrants to higher education (Tinklin & Raffe, 1999);
- Gender and low achievement (Biggart, 2000);
- High-attaining female school leavers (Tinklin, 2000);
- Early entrants to the labour market, and participants in government training (Howieson et al., 2000);
- Young people not in education, employment or training (NEET) (Croxford & Raffe, 2000).

## WHAT ARE THE PURPOSES OF SCIENCE EDUCATION?

The Science Strategy suggests that science education has two important purposes:

1. To ensure that young people entering the Scottish workforce of the 21st century have the knowledge and skills necessary to promote economic, scientific and technological development;

2. To give the future citizens of Scotland an understanding of scientific and technological approaches and evidence, so that they will be able to make informed decisions on scientific and technological issues.

Clearly, these two purposes are linked and indicate the importance of ensuring that all young people have a good education in science and technology so that as citizens and members of the workforce they can engage critically and creatively with opportunities and issues relating to technology and science.

Scotland is not alone in giving priority to science education. Throughout Europe, education policy makers allocate high priority and considerable resources to the teaching of science and technology with the aim to educate the scientists, technologists and technicians on whom future economic development is perceived to depend (Benavot, 1992; Driver *et al.*, 1996). There is a further challenge to improve public understanding of science and to improve levels of scientific literacy (Ryder, 2001).

In 2001, HM Treasury commissioned a review of the supply of scientists and engineers in the UK:

> *Scientists, mathematicians and engineers contribute greatly to the economic health and wealth of a nation. The UK has a long tradition of producing brilliant people in these areas, from Isaac Newton and Isambard Kingdom Brunel to Dorothy Hodgkin and Nevill Mott last century, and most recently to Andrew Wiles who proved Fermat's Last Theorem. The challenge we face is to continue to attract the brightest and most creative minds to become scientists and engineers".* (HM Treasury, 2002 (The Roberts Review), "Forword")

However, there may be a tension in policies for science education between the desire to *"attract the brightest and most creative minds"* - and perhaps produce one or two Nobel prize winners - and the need to encourage participation in technology and science by all future citizens, workers and entrepreneurs in Scotland. This will be discussed later in the report.

## WHAT DO WE MEAN BY SCIENCE?

The definition of science used by the Science Strategy is extremely broad:

> *"Science can mean different things to different people and in different contexts. For the purposes of this strategy science has been interpreted to encompass the development, understanding and the application of the **physical, life and social sciences**. Our approach to science can naturally be extended to **engineering and technology**."* (Scottish Executive, 2001b), Introduction)

The breadth of this definition poses problems for the current study in view of the need to identify "science" in schools as well as in higher education. The secondary school curriculum in Scotland includes 'Scientific studies and applications' as a mode of study, within which specific subjects are taught: chemistry, physics, biology and (general) science. Social science is not easily identified within the school curriculum; the 'Social and environmental studies' mode includes history, geography, modern studies, economics and classical studies' and the factors influencing participation in these subjects are unlikely to be the same as factors influencing subjects in the scientific studies mode. The 'Technological activities and applications' mode includes a number of separate subjects including technological studies, craft and design, graphic communication, computing, office/management and information studies, and home economics.

In further and higher education a range of subjects are potentially related to science:
Group A: Medicine and Dentistry
Group B: Subjects allied to medicine
Group C: Biological sciences
Group D: Agriculture and related subjects
Group F: Physical sciences
Group G: Mathematical sciences and informatics (including computing)
Group H/J: Engineering and Technology
Group L/M: Social studies.
(Universities and Colleges Admissions Service, 2002)

However, for the current study we will focus on science, engineering and technology (SET), including:

- biological sciences,
- physical sciences,
- mathematical sciences and informatics (including computing),
- engineering and technology.

This narrower definition is similar to that used in the Roberts Review (HM Treasury, 2002).

## WHY ARE LEVELS OF PARTICIPATION IN SCIENCE, ENGINEERING AND TECHNOLOGY (SET) CONSIDERED TO BE A PROBLEM?

Levels of participation in science and technology in school and in post-school education have not matched the expectations of policy makers, and there is continuing concern to find the reasons why young people decide not to study science and technology. The European commissioner for research stated recently:

> *"We are currently in a paradoxical situation. While science and technology play key roles in today's global economy, young people are turning away from science subjects. Clearly, raising interest in science among young people is necessary for increasing the number of future science professionals."* (Busquin, 2001)

The Roberts Review reported that while the aggregate number of students with broadly scientific and technical degrees has risen in the last decade, with notable increases in computing science, there have been significant falls in the numbers taking physics, mathematics, chemistry and engineering qualifications. It warned that these downward trends, combined with deficiencies in transferable skills among graduates, could undermine the Government's attempts to improve the UK's productivity and competitiveness (HM Treasury, 2002). The review warned also that declining numbers, coupled with increasing demand from a number of sectors for graduates in mathematics, engineering and physical science, was likely to lead to shortages in supply of these scientific and technical skills. It identified related problems in the supply of teachers in these shortage areas.

The review commented that the proportion of higher education students studying science and engineering was relatively higher in Scotland than in England: whereas 5.8% of all entrants to higher education in the UK came from Scotland the proportions were 7.4% in the biological sciences, 6.4% in the physical sciences and 9.3% in engineering (*op. cit.* p68, para 2.87). However, in spite of the relatively strong levels of participation in science and engineering in Scotland, science subject areas have not shared fully in the general increase in participation in higher education. The Scottish Higher Education Funding Council (SHEFC) reports that between 1996-7 and 2001-2 the numbers of full-time equivalent students eligible for funding by SHEFC increased by 3.5% overall, but numbers in computing and information science increased by 45.5%, and in mathematics and statistics by 4.1%, whereas in science numbers increased by 1.6% and numbers in engineering and technology declined by 5.6% (Scottish Higher Education Funding Council, 2002).

Since the 1960s there has been a great deal of research into possible reasons for low levels of participation in science. Explanations, which are inter-linked, include:

- images of science;
- relative difficulty of science subjects;
- low status of technology subjects;
- gender differences;
- the system of subject choice in schools;

- occupational awareness and careers guidance;
- problems of student finance.

### Images of science

A study of young people's images of science suggests that many young people may see science as the accumulation of 'facts' about the natural world, and adopt a passive or 'rote' learning style which is inefficient at best, or decide that science is not for them (Driver *et al.*, 1996). The authors argue that public understanding of science should include awareness that the aim of science is to establish explanations for the behaviour of natural objects and phenomena that can command widespread acceptance. Similarly, a recent on-line survey of UK students found that over half of young people thought that GCSE science tested the ability to memorise things rather than understanding, and felt that there should be more emphasis on comprehending why things worked, rather than how. Over two-thirds of students wanted more chance to debate controversial topics such as cloning and genetic engineering in their school science classes (BBC News, 2002).

Common images of SET are seen to have a negative impact on levels of participation. Some researchers have identified SET as having a 'masculine' image which was off-putting to females (Kelly *et al.*, 1987; Roger & Duffield, 2000). Scientists have had a "bad press" with respect to a number of recent scientific controversies; for example there has been public anxiety about the Mumps, Measles and Rubella Vaccine because scientific evidence has been questioned by some sections of the media. In addition, the public images of careers in SET have sometimes been tarnished by the environmental and economic problems of manufacturing industry (Munro & Elsom, 2000).

There have been a number of recent events and activities aimed at improving the public image of science. For example, the *Science Year*, from 7th September 2001 to 31st August 2002 throughout the UK provides events and resources:

> "*designed to stimulate the imagination about science and technology...It's for everyone, but it's focused particularly on people between the ages of 10 and 19 and the adults around them - especially their teachers. Science Year isn't about test-tubes, voltmeters and bunsen burners though. It's about raising awareness of the wide and wonderful world of subjects and careers that are underpinned by science and technology*" (Department for Education and Skills, 2002)

However, awareness of these events by young people at school is limited. Other events in recent years include the Edinburgh Science Festival, and roadshows, events and websites with a range of science-based activities to enhance the enjoyment of science by pupils organised by Scottish Universities. There have also been enhanced opportunities for continuing professional development (CPD) of science teachers.

### Relative difficulty of science subjects

There is a widely-held perception that science subjects, especially physical sciences, are relatively more difficult subjects than arts and social subjects (Duckworth, 1978; Kelly, 1987; Tinklin *et al.*, 2001; HM Treasury, 2002). To some extent these perceptions may be associated with the theoretical and factual content of science courses. Science, maths and engineering subjects tend to require the study of considerable amounts of core knowledge, and understanding new concepts often means building on other concepts already studied and understood. In school, the perception of relative difficulty is linked to the greater probability of high attaining pupils attempting physics than low attaining pupils (Croxford, 1997). Many schools direct pupils with lower attainment to study the (general) science course at Standard Grade, rather than individual science subjects.

Undergraduate science and technology courses are perceived be students to be ‘hard’ - both in the sense of being conceptually difficult, and in the sense of taking considerable time and effort to study. The Roberts Review notes that contact hours for SET typically exceed those for arts and humanities courses; more than 25 contact hours per week for scientists is not unheard of, whereas 10 or fewer contact hours is not uncommon for some arts and humanities courses (HM Treasury, 2002, page 93).

**Low status of school technology**

In British schools there is a strong division between science and technology arising in the past from the academic traditions of science departments compared with the more practical ‘craft’ focus of technology departments (McCulloch *et al.*, 1985). Over the last two decades curriculum developments within the technological mode have brought considerable academic rigour to school technology, so that the academic hierarchy of the past is not appropriate. As a result of the Higher Still reforms, a number of new engineering courses have been developed for study within the same qualifications framework as the traditional academic courses. Nevertheless, the continuing division of subjects between modes of the curriculum, and the divisions between subject departments in secondary schools, reduces opportunities for knowledge and skills developed within the technology curriculum to feed into the science curriculum, and *vice versa*. The need to bring science and technology together within the school curriculum was one of the recommendations of Callaghan’s Ruskin speech. More recently, there have been calls by manufacturing industry in the UK to make the science curriculum more relevant to pupils’ everyday lives (Engineering Employers Federation, 2002).

**Gender differences**

Gender differences in participation in SET have been well documented: more females than males study biological science, but relatively few females choose physical science, engineering or technology at school or in higher education (Kelly, 1987); (Croxford, 2000). A number of initiatives have been developed to try to encourage females to enter SET courses in higher education (Roger & Duffield, 2000). However, the choice of science courses at school are a key influence on subsequent patterns of participation. A recent research study in Scotland found that reasons for gendered patterns of participation in science include attitudes and stereotypes, perceived vocational relevance, intrinsic interest in the subject and perceived difficulty (Tinklin *et al.*, 2001). These findings echo those of research in the 1980s which found that whereas boys have sufficient self-confidence to choose to study physical science subjects in spite of their difficulty, girls have less self-confidence and tend to prefer and choose the subjects they think are easier - even girls who achieve good results in physical science seem to lack the self confidence to choose these difficult subjects (Omerod, 1981). One of the teachers interviewed by the Gender and Pupil Performance project explained:

> “*Physics is seen very much as a boys subject. And when it comes to the option choice time in 2nd year there might be a tendency on the part of the more able girls to opt for the Biology/Chemistry side than to get into the Physics/Engineering side...I think there must be a number of girls out there not achieving their potential, particularly in the Physics side, as a result of stereotyped thinking in terms of their careers and what’s for them*”. (Physics teacher quoted in Tinklin *et al.*, 2001, p 25)

## The system of subject choice in schools

Up to the age of about 14 years, the S2 stage, all pupils study a common curricular programme which includes elements of science and technology. At the end of S2 pupils choose up to eight subjects they will study for Standard Grade. The extent of choice is limited by the national curricular guidelines, so that all pupils must study at least one science subject. However, at this stage pupils have the opportunity to choose between chemistry, physics and biology. Unfortunately, for historical reasons the (general) science option at Standard Grade has been perceived to be suitable for the lower ability pupils, whereas the more able pupils are expected to specialise in one or more of the individual science subjects. At this stage most students opt to study just one science subject, which for the majority of girls is biology. This premature specialisation may be a contributory factor in low levels of participation in science, engineering and technology in higher education (Roger & Duffield, 2000). Because the development of knowledge and understanding in science is incremental, once 'dropped' science subjects are much harder than other subjects to return to later.

National curricular guidelines recommend that all pupils should study one subject in the technological activities mode. However, there is some flexibility in the guidelines, and the way in which the subject choice forms are designed by schools tends to make study within the technological activities mode optional. There are very strong gender differences in participation in subjects within this mode, with more females than males studying office and information studies and home economics, while more boys than girls take technological studies, craft and design, graphic communication and computing (Tinklin *et al.*, 2001). The main reasons given by young people for their subject choices were summarised by the Gender and Pupil Performance project as "subjects they liked, those they were good at, and those which they thought would be useful for entering the careers they had in mind" (*op. cit.* p23).

The importance of guidance for pupils when making their subject choices, including advice about careers implications, is well recognized in schools. However, a recent research project in Scotland, *Guidance in Secondary Schools* (Howieson & Semple, 1996) found that the majority of pupils were critical of the S2 option choice process, and many felt they would have liked a greater careers input and longer course choice interview to enable them to consider the options in greater depth. At the S4 and S5 stages young people felt they had even less information and support than at S2, and that there was insufficient time and little if any discussion of their career ideas. The issue of guidance for subject choice relates to the importance of careers education and guidance – the report notes that *"Pupils of all attainment levels felt they were not aware of the full range of possible courses and jobs and found it difficult to assess what would be the best option for them"* (*op. cit.* p. x).

## Occupational awareness and careers guidance

A recent study in England of the influences of science teachers and careers advisers on students decisions to study SET found that young people had very limited awareness of careers in SET, and decisions taken about science subjects very early in school could cut them off from a range of scientific, medical and engineering careers (Munro & Elsom, 2000). The research found that science teachers were an important influence on young people's decisions about science subjects, through pupils' experiences of science in the classroom, extra-curricular activities, and discussion with individual pupils and their parents how the pupil might cope with more advanced study. It recommends that links between science curriculum and future careers should be raised more explicitly in the earlier secondary stages.

The report notes that many young people have "switched-off" science before they have an interview with a careers adviser at Year 11 (equivalent to S4) and that careers input would be more useful at the earlier secondary stages "*to increase pupils' (and parents') awareness of* *the width of opportunities available to people with science qualifications, and to do so before attitudes to the subjects harden and important choices are made without their consequences being fully understood." (op. cit.* para ES.23)

The Roberts Review makes recommendations for supporting careers education and guidance in schools in order to raise awareness of links between school science and potential career opportunities, and increase knowledge about rewards and breadth of careers arising from studying SET (HM Treasury, 2002, p78-80).

### Problems of student finance

In higher education, problems of student finance have become a key issue for participation because students face the prospect of large debts at the end of their studies. Many students need to undertake part-time work in order to finance higher education studies, and the Roberts Review notes that students of SET face problems because their courses require long contact hours which restrict their opportunities to undertake part-time work (HM Treasury, 2002, p104-5). Non-traditional students face major financial barriers to higher education, and are more likely to study shorter sub-degree courses, and attend local less-prestigious institutions in order to minimise their potential student debts (Forsyth & Furlong, 2000).

Graduate employment opportunities, perceived salary prospects, and expectations for paying-off student debts are key factors in the choice of subjects studied within higher education. Clearly, perceived opportunities in computing and finance have led to the popularity of courses in informatics and business studies (Forsyth & Furlong, 2000). However, career and employment opportunities in other areas of SET are not clearly evident. Policies to expand participation in SET will need to provide evidence to students that these courses will enhance their career prospects.

## POLICIES TO EXPAND PARTICIPATION IN SET

Expansion of participation in SET has been a priority for policy-makers for several decades. For example, the 1963 Robbins Report (Committee on Higher Education, 1963) led to major expansion of places in science and engineering faculties in universities. Subsequently, in 1976 James Callaghan's speech at Ruskin College Oxford, which opened the '*Great Debate*', emphasised that science education should be relevant to the needs of industry in the 20th century (Callaghan, 1977). In 1993 the White Paper "Realising Our Potential" called for:

> "*increased scientific education for all and greater attention to the development of the next generation of highly qualified science and technology personnel"* (HM Government, 1993)

In 2001, the Science Strategy for Scotland included policies to improve participation in science within school education and post-school education. Policies for schools included:

- advice by Learning and Teaching Scotland of how to ensure that all school pupils have the opportunity to acquire the capacity to cope as citizens and decision makers with scientific issues;
- improved teaching materials and assessment methods;
- additional teachers and greater attention to Continuing Professional development (CPD);
- improved accommodation and resources for science education;
- activities to promote interest in science.

Policies for post-school education included:

- an analysis by Future Skills Scotland of the supply and demand for people with science qualifications;

- improvements to post-school science courses to enhance generic skills including communication skills;
- improved information and advice about careers.

(Scottish Executive, 2001b, Section 3)

**Recommendations by the Roberts Review for the UK as a whole**

School and further education:

- action to increase participation of women in science and engineering;
- action to increase achievement and participation in science and engineering by ethnic minority groups;
- greater subject-specific training for primary school teachers;
- improved recruitment and training of secondary-school science teachers;
- enhancements to pay and incentives for teachers in mathematics, science, Information and Computing Technology (ICT) and design and Technology (D&T);
- improvements to science teachers' access to Continuing Professional Development (CPD);
- investment in improvements to school laboratories;
- employment of skilled teaching assistants to support science and D&T teachers;
- modernisation of science curriculum;
- improved transition from GCSE to A-level;
- research into the greater apparent difficulty of science and mathematics examinations;
- co-ordination of schemes aimed at enthusing pupils in science and engineering;
- improvements in careers advice with respect to science and engineering.

Undergraduate education:

- improved transition from A-level to degree-level courses;
- updating of the nature and content of undergraduate courses;
- investment in the equipment and refurbishment of university teaching laboratories;
- review subject-teaching funding for science and technology subjects;
- greater provision of access funds and hardship funds to provide adequately for students with a high number of contact hours.
- enhancement of university careers advisory service.

(HM Treasury, 2002, Annex A.)

# CHAPTER 2: SCIENCE AND TECHNOLOGY IN COMPULSORY SCHOOLING

Young people's experience of science and technology in compulsory schooling provides the foundation for their scientific awareness and subsequent study of SET. This section therefore describes patterns of participation in science and technology courses at Standard Grade in the S3 and S4 stages. It considers the following questions:

- What are the national curricular guidelines for the compulsory stages of schooling, and how do they influence levels of participation in science and technology?
- Which science and technology subjects are studied at Standard Grade by males and females, and by low and high attaining pupils?
- Do other background factors influence the choice of science and technology subjects?

## NATIONAL CURRICULAR GUIDELINES

National curriculum guidelines for Scottish schools are developed by the Scottish Consultative Council on the Curriculum (SCCC, now Learning and Teaching Scotland). The guidelines set out a common curriculum to be taught in all schools. The guidelines relating to science and technology ensure that all pupils have opportunities to learn about these curricular areas during the years of compulsory schooling.

### 5-14

The 5-14 curriculum guidelines cover the primary stages and the first two years of secondary schooling curriculum. There are five main areas of the curriculum:

- Language;
- Mathematics;
- Environmental studies;
- Expressive Arts;
- Religious Education. (Scottish Office Education Department, 1993)

Science and technology are included in the *Environmental Studies 5-14* curricular guidelines (Scottish Executive, 2000a). The science curriculum includes understanding: living things and processes of life; energy and forces; earth and space. The technology curriculum focuses on "Technological capability". As well as knowledge, understanding and skills, the environmental studies curriculum is also concerned with "developing informed attitudes".

The national guidelines for science were first published in 1993, and revised in 2000. Although the 5-14 National Guidelines are intended for the first two years of secondary schooling in addition to the primary stages, a report by HMI in 2000 noted that in general the rate of implementation of the national guidelines had been slow (Scottish Executive, 2000b).

### S3 and S4 stages

The curriculum for the last two years of compulsory schooling, the S3 and S4 stages, is divided into eight modes of study:

- Language and Communication
- Mathematical Studies and Applications
- Scientific Studies and Applications
- Social and Environmental Studies
- Technological Activities and Applications
- Creative and Aesthetic Activities

- Physical Education
- Religious and Moral Education

(Scottish Consultative Council on the Curriculum, 1999)

In order to ensure that pupils experience a broad and balanced curriculum the national guidelines advise that all pupils study subject courses within each of the eight modes. Pupils have a choice of subjects within scientific studies and technological activities modes. Within the mathematical studies mode all pupils must take mathematics. Most of the courses studied by pupils in S3-S4 are prepared for Standard Grade examinations,[1] and their content is determined by the Scottish Qualifications Authority (SQA).

Before the national guidelines were introduced in 1983, many pupils did not study any science in the S3 and S4 stages. There were considerable differences in participation by gender and social class: in 1983 a girl whose father was in a manual occupation had a 55% probability of studying any sciences, compared with 70% for a boy from a manual background, and 75% and 85% respectively for girls and boys from a non-manual backgrounds (Croxford, 1994). The introduction of national curricular guidelines included a recommendation that priority be given to English, mathematics and science, and led to an increase in overall levels of participation in science subjects. By 1991 all pupils in Scotland studied at last one science subject until the end of compulsory schooling at age 16.

The technological activities mode, which includes technological studies, craft and design, graphic communication, computing, office/management and information studies, and home economics, was not given as much priority as scientific studies in the development of national guidelines. The mode was not included in the "core" curriculum until 1989, when the Technical and Vocational Education Initiative (TVEI) provided resources and priority for technological education in schools. In 1991 three-quarters of pupils studied at least one subject within the technological activities mode.

## SUBJECT CHOICE

The final two years of compulsory secondary education, the S3 and S4 stages, provide the first opportunity for young people to choose the subjects they wish to study. At the end of S2 pupils choose which subjects they will continue, and which subjects they will drop, and subsequently during S3 and S4 pupils study up to eight subject courses for Standard Grade examinations. National curricular guidelines recommend that pupils should study at least one subject in the scientific studies mode, and one in the technological activities mode. In practice, schools have some flexibility in implementing the curricular guidelines (Scottish Executive 2001), and need to take account of available staff, accommodation and timetabling constraints. Schools typically organise the process of subject choice by providing pupils with option choice forms giving a limited number of options from which to choose. Typically, the option choice system constrains pupils to study no more than two science subjects, and makes study within the Technological Activities mode optional.

Pupils' choice of subjects at this early stage is very important in determining subsequent participation in science, engineering and technology. Pupils must choose which science and technology subjects they will study in future, and whether to give priority to science (by choosing two or three science subjects) or to give priority to languages, social studies, or arts.

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[1] Standard Grade courses are provided at Foundation, General and Credit level to cater for pupils of all levels of ability; Foundation courses cater for pupils with low levels of attainment, and Credit courses for pupils with high levels of attainment. Typically, students study at two levels - Foundation/General or General/Credit. Following the introduction of Higher Still in 1999-2000 some schools have started to use Access courses in S3-S4 instead of SG Foundation, and Intermediate courses instead of General and Credit. However this is a relatively recent development which did not apply to young people in 1998.

It could be argued that pupils are required to specialise in particular aspects of science before they have sufficient awareness of the implications of the choices they are making. In the S1 and S2 stages schools typically provide pupils with a short introduction to each subject. Pupils tend to choose subjects they enjoyed, those they thought they were good at, and those they thought would be useful in a future career.

Schools provide some guidance to pupils and their parents during the subject choice process, including raising awareness of equal opportunities, and careers implications (Tinklin *et al.*, 2001). Many young people tend to be very unclear in their career ideas at the end of S2, and are advised to choose subjects that will "keep their options open". A study of guidance in Scottish schools found that many pupils would have liked a greater amount of advice about the careers implications of their subject choices (Howieson & Semple, 1996). A significant proportion (23%) of the young people surveyed by the Scottish School Leavers Survey (SSLS) in spring 1998 felt that their secondary school teachers did not give them enough help with choosing subjects at the end of 2nd year.

## SCIENCE SUBJECTS STUDIED IN S3-S4

Analysis of the SSLS, linked to data from the Scottish Qualifications Authority (SQA), shows that (almost) all pupils attempted at least one subject in the scientific studies mode at Standard Grade in S4 in 1998 (Table 2.1). Chemistry proved to be the most popular science subject, and was studied by 40% of all pupils. It is interesting to note also that chemistry was studied by almost equal proportions of females and males, whereas there were gender differences in participation in other science subjects. Over half of girls studied biology compared with less than a quarter of boys (52% vs 22%), while the position was reversed for physics (studied by 21% of girls and 44% of boys). A quarter of all pupils studied the general science course, with a slightly higher proportion of boys studying this option. These gender differences in participation in science subjects follow long established trends reported by previous research (Croxford, 1997).

**Table 2.1: Science subjects attempted at Standard Grade in S4, 1998 by gender (%)**

| | Females | Males | All |
|---|---|---|---|
| Chemistry | 38 | 41 | 40 |
| Physics | 21 | 44 | 33 |
| Biology | 52 | 22 | 37 |
| (General) Science | 23 | 28 | 25 |
| At least one of the above science subjects | 98 | 98 | 98 |
| 2 or more individual science subjects | 32 | 34 | 33 |
| • Physics & Chemistry | 13 | 25 | 19 |
| • Biology & Chemistry | 20 | 10 | 15 |
| • Physics & Biology | 5 | 5 | 5 |
| **Core subjects** | | | |
| Mathematics | 99 | 98 | 98 |
| English | 98 | 98 | 98 |
| *unweighted N (=100%)* | *4118* | *3323* | *7441* |

Differences between high and low attaining pupils in choice of science subjects are summarised by Table 2.2. Ideally, the measure of attainment used for the analysis would be based on prior attainment at the end of S2, but since this is not available the measure of attainment used for this analysis is based on each young person's attainment at Standard Grade.[2]

[2] The S4 Standard Grade attainment measure is derived from a point score (calculated by allocating 7 points for each award at 1, 6 points for each award at 2...., and 1 point for each award at 7). The distribution of point scores was divided into five bands, each of which encompassed one-fifth of the weighted sample at Sweep 1, and described broadly as "very low", "low", "medium", "high" and "very high".

**Table 2.2: Science subjects attempted at Standard Grade in S4, 1998 by level of attainment (%)**

| | Attainment at Standard Grade | | | | |
|---|---|---|---|---|---|
| | **Lowest** | **Low** | **Medium** | **High** | **Highest** |
| **(SG point score)** | **(0-27)** | **(28-35)** | **(36-43)** | **(44-52)** | **(53-75)** |
| Chemistry | 10 | 21 | 41 | 58 | 75 |
| Physics | 7 | 17 | 35 | 49 | 60 |
| Biology | 13 | 31 | 45 | 49 | 48 |
| (General) Science | 67 | 41 | 12 | 2 | 0 |
| Two or more sciences | 4 | 10 | 32 | 53 | 71 |
| *unweighted N (=100%)* | *1075* | *1276* | *1709* | *1793* | *1585* |

Two-thirds of pupils in the lowest attainment group studied (general) science, but no pupils in the highest attainment group chose this option. The (general) science option is seen as a means of providing an easier science course for lower-attaining pupils, and very few pupils attempt credit-level examinations in (general) science. On the other hand, the likelihood of studying of chemistry and physics was strongly related to attainment; just 10% of pupils in the lowest attainment group took chemistry, compared with three quarters of pupils in the highest attainment group. Similarly just 7% of the lowest attainers compared with 60% of the highest attainers studied physics. The relationship between attainment and studying biology was not as strong as for the other subjects, however: there was little difference between pupils with medium, high and highest attainment in the likelihood of studying biology.

These findings tend to confirm that physics and chemistry are generally perceived to be relatively difficult academic subjects, and are therefore studied to a greater extent by high-attaining pupils.

The number of science subjects studied in S4 provides an indication of the priority given to science in pupils' subject choices. In addition, studying more than one science or technology subjects at Standard Grade is likely to reinforce the appropriate skills of analysis, data handling, IT and numeracy so that young people who have studied more than one science or technology subject are more confident in their ability to study these subjects in future. Two-thirds of all pupils studied just one science subject in S4. The largest proportion of pupils taking just one science studied general science (38%), while 30% studied biology, 18% physics and 14% chemistry (table not shown). A minority of pupils (30%) studied two science subjects in S4, and only 3% attempted three science subjects. Pupils with the highest levels of attainment were much more likely than average to study two or more science subjects.

All pupils studied mathematics at Standard Grade, but the curriculum differed according to level; the course for pupils studying at Credit level is a great deal more demanding than the syllabus at General, and similarly, the course at Foundation level is more demanding than at Foundation level. Level of study in mathematics is an important contributory factor in young people's confidence in scientific skills, and subsequent participation in science (Chapter 3).

## TECHNOLOGY SUBJECTS STUDIED IN S3-S4

For the purposes of this study technology subjects at school include computing, craft and design, graphic communication and technological studies. This is a narrower definition than is used by the technological activities and applications mode of the national curricular guidelines which includes office/management and information studies and home economics.

**Table 2.3: Technology subjects attempted at Standard Grade in S4, 1998 (% of females and males)**

| | Females | Males | All |
|---|---|---|---|
| Technological studies | 1 | 13 | 7 |
| Craft and design | 9 | 34 | 22 |
| Graphic communication | 6 | 18 | 12 |
| Computing | 24 | 40 | 32 |
| At least one of the above technology subjects | 36 | 78 | 57 |
| 2 or more technology subjects | 3 | 25 | 14 |
| • Craft and design & computing | 1 | 8 | 5 |
| • Craft and design & graphic communication | 1 | 6 | 3 |
| • Graphic communication & computing | 1 | 5 | 3 |
| *unweighted N (=100%)* | *4118* | *3323* | *7441* |

Over half of all pupils attempted at least one of the technology subjects at Standard Grade, but the proportion was much greater among males than females (Table 2.3). Computing was the most popular subject, and was studied by about one third of all pupils - 40% of boys and 24% of girls. Craft and Design was studied by one third of males but only 9% of females.

Table 2.4 shows that the relationship between attainment and study of technology subjects was not as strong as for science subjects. Low attaining pupils were more likely to study craft and design than high attaining pupils, and the reverse is true for computing. Proportions studying technological studies were very low for all attainment groups. The proportion studying graphic communication was a little higher among the pupils in the middle of the attainment range.

**Table 2.4: Technology subjects attempted at Standard Grade in S4, 1998 by level of attainment (%)**

| | Attainment at Standard Grade | | | | |
|---|---|---|---|---|---|
| | Lowest | Low | Medium | High | Highest |
| Technological studies | 7 | 8 | 8 | 7 | 6 |
| Craft and design | 32 | 32 | 20 | 14 | 8 |
| Graphic communication | 7 | 13 | 15 | 14 | 11 |
| Computing | 21 | 32 | 35 | 36 | 36 |
| At least one of the above | 55 | 62 | 61 | 57 | 51 |
| Two or more | 11 | 20 | 16 | 13 | 9 |
| *Unweighted N (=100%)* | *1075* | *1276* | *1709* | *1793* | *1585* |

Only 14% of pupils studied more than one technology subject, 25% of males and only 3% of females. Clearly, the study of technology did not receive high priority in the subject choices of the majority of young people.

## FACTORS INFLUENCING THE SCIENCE AND TECHNOLOGY SUBJECTS STUDIED IN S3-S4

Factors influencing the science and technology subjects studied in S4 were analysed using a series of multilevel logistic regression models. The multilevel structure of the models allows for variation between schools in addition to estimating the average differences between pupils with different characteristics. The models looked in turn at each of the science and technology subjects studied for Standard Grade in S4, and estimated the average effect of each explanatory variable “net” of all other variables. Detailed results are provided in Appendix Tables 1-3, but the main findings are summarised here.

The main explanatory factors identified by the model were:

- Standard Grade attainment;
- sex;
- whether the young person aspired to go to university;
- whether parents had experienced post-compulsory schooling;
- parents' occupation;
- local area deprivation;
- type of school.

Other factors which were included in the models but found not to be statistically significant were family structure, home ownership and average school social context.

### Standard Grade attainment

We have seen above that the choice of science subjects to be studied for Standard Grade is strongly influenced by the levels of attainment each young person is expected to achieve. Attainment is the strongest influence on choice of science subjects, even when all other factors are held constant by the statistical models. There is a relationship between attainment and choice of technology subject, but this is not as strong as that for science subjects.

### Sex

To some extent the gendered pattern of participation in science and technology subjects has been described with reference to the raw percentage distributions in Tables 1 and 3. However, the statistical models estimate the effects of gender net of all other factors, and therefore take into account the lower average S4 attainment of males compared with females. When attainment is taken into account, there is no further difference between males and females in levels of participation in (general) science, but there is a strong gender effect on other science subjects, with males of given attainment more likely than females to study chemistry, much more likely to study physics, and less likely to study biology.

The influence of gender is stronger than that of attainment in predicting participation in technology subjects, all of which are more likely to be studied by males than females.

### University aspirations

The SSLS questionnaire included a question asking young people whether they agreed or disagreed with the statement "I would like to go to university and get a degree". Over half of young people agreed with this statement: 61% of females and 53% of males.

Pupils who aspired to go to university were less likely to study (general) science than those who did not - this effect is found after taking account of pupils' attainment and sex. Pupils who aspired to go to university were more likely to study physics and chemistry in S4 than pupils who did not have university aspirations. Amongst those with university aspirations there was a smaller gender-gap in probability of studying physics than was found among other pupils. There was no difference in probability of studying biology between pupils who wanted to go to university and those who did not want to go.

Pupils who said they wanted to go to university were less likely to study craft and design and more likely to study graphic communication and computing in S4 than pupils who did not have university aspirations. Amongst those with university aspirations there was a smaller gender-gap in probability of studying graphic communication than was found among other pupils. There was no difference in probability of studying technological studies between pupils who wanted to go to university and those who did not want to go.

### Family background

Family background, including parents' education and occupation, has an important influence on pupils' attainment. However, it is interesting to note that after taking account of the effects of pupils' attainment there is an additional effect of family background on the choice of subjects studied. Pupils whose parents had some post-compulsory education were more likely to study chemistry or biology, and less likely to study (general) science and craft and design than their peers. Similarly, pupils whose parents were in professional or intermediate occupations were more likely to study chemistry, physics or biology, and less likely to study (general) science. However, there is no evidence that parents' occupation had an effect on technology subjects studied.

A possible reason for the effects of family background is that parents' advice about subject-choice and careers is very important to young people (Howieson *et al.*, 1993) and it is likely that parents with more experience of education, or in high-status occupations, may have been in a better position to advise their children of the benefits of studying individual science subjects.

### Local-area deprivation

The new index of deprivation developed on behalf of the Scottish Executive (Gibb *et al.*, 1998) provides a measure of relative deprivation in the home area. The analysis found that young people in areas of deprivation were more likely to study chemistry and less likely to study biology. There was no evidence that the choice of technology subjects varied by local-area deprivation.

### School type

Pupils attending independent schools had a greater probability of studying physics and biology than their peers in state-funded schools. Girls attending independent schools had a greater probability of studying physics than girls attending state-funded schools and therefore the gender gap was smaller in independent schools. Pupils in independent schools did not study (general) science, and were much less likely to study any technology subjects than their peers in state-funded schools. Males attending independent schools had a lower probability of studying computing than boys attending state-funded schools and therefore the gender gap in computing was smaller in independent schools.

### School differences

After controlling for all the factors in the model, there was significant variation between schools in the proportion of pupils studying each of the science and technology subjects in S4. These school differences could not be explained by any systematic factors available in the dataset such as average socio-economic context or average attainment. It is likely that much of the variation is due to differences in school resources, such as availability of staff with each subject specialism.

**Table 2.5: Credit-level awards at Standard Grade in S4 (% of females and males)**

| | Females | Males | All |
|---|---|---|---|
| **Science subjects** | | | |
| Biology | 31 | 13 | 22 |
| Chemistry | 27 | 26 | 27 |
| Physics | 17 | 30 | 24 |
| (General) Science | 1 | 1 | 1 |
| 1 or more individual science subjects | 47 | 43 | 45 |
| 2 or more individual science subjects | 24 | 24 | 24 |
| • Chemistry and Physics | 14 | 26 | 19 |
| • Biology and Chemistry | 18 | 10 | 15 |
| • Physics and Biology | 6 | 6 | 6 |
| **Technology subjects** | | | |
| Technological Studies | 1 | 6 | 3 |
| Craft and design | 4 | 10 | 7 |
| Graphic Communication | 3 | 7 | 5 |
| Computing | 11 | 16 | 14 |
| 1 or more technology subjects | 17 | 32 | 25 |
| 2 or more technology subjects | 1 | 6 | 4 |
| **Core subjects** | | | |
| Mathematics | 35 | 33 | 34 |
| English | 48 | 35 | 41 |
| **Combinations** | | | |
| Mathematics with 2+ science | 21 | 20 | 21 |
| Mathematics with 2+ science and technology | 7 | 13 | 10 |
| *N (=100%)* | *2834* | *2085* | *4919* |

## ATTAINMENT IN SCIENCE AND TECHNOLOGY AT THE END OF S4

Attainment in technology and science at the end of compulsory schooling is summarised in Table 2.5, in terms of credit-level awards at Standard Grade. Attainment at credit-level (an award at 1 or 2) is a requirement for young people who wish to study a subject at Higher Grade. Table 2.5 shows that almost half of the SSLS cohort achieved a credit-level award in a science subject, almost a quarter achieved an award in a technology subject and one third of young people achieved a credit award in mathematics. One fifth of young people had achieved credit level awards in two sciences plus mathematics.

Gender differences in attainment are related to differences in participation in each subject (Table 2.1). However, females have higher levels of attainment and are more likely than males to achieve credit level awards in every science or technology subject they attempt (Tinklin *et al.*, 2001).

## SUMMARY

National curriculum guidelines ensure that all pupils study science throughout compulsory schooling. Less priority has been given to technology.

The S3-S4 stages, when pupils study Standard Grade courses, are their first opportunity to choose which subjects to study, which to specialise in, and which to drop.

Many pupils said that would have liked more advice than was currently available when making their subject choices.

All pupils studied at least one science subject up to the end of S4, and one third studied two or more science subjects.

Half of all pupils studied at least one technology subject:

The strongest influence on young people's choices of science and technology subjects in S3-S4 were gender and attainment. Other factors were university aspirations, family background, local-area deprivation and type of school.

## ISSUES ARISING FROM THE STUDY

The priority given to science (together with English and mathematics) in national curriculum guidelines has ensured that all pupils have some experience of science throughout their compulsory schooling. It might be argued, therefore, that at least one of the aims of science education - to ensure public understanding of scientific issues - is some way to being achieved.

However, this depends on the content of the science courses, and the emphasis given by teachers. For example, the aims and objectives of individual science courses such as Chemistry include:

> *"The course contributes to their general education by helping to make them aware of the applications of chemistry/science in everyday life."*

and

> *"Pupils should:*
> - *be open-minded and willing to recognise alternative points of view;*
> - *develop an interest in science, in themselves and their environment;*
> - *be aware that they can take decisions which affect the well-being of themselves and others and the quality of their environment".* (Standard Grade Revised Arrangements in Chemistry, General and Credit levels)

Nevertheless, the examinations focus exclusively on scientific content, and in the pressure to prepare pupils for examinations it may be difficult for teachers to find time to encourage discussion and questioning of the issues pupils need to be aware of as future citizens and consumers of science.

The choice of subjects to be studied for Standard Grade is an important factor in young people's subsequent curricular pathways and career opportunities, yet subject choice is currently made at the end of S2 when the majority of young people are very unclear about their career options and preferences. Over a fifth of young people in the SSLS cohort expressed the wish for more help in making these choices. Other studies have emphasised the need for more careers guidance to be provided at earlier stages of schooling in order to help young people to develop their career ideas and make appropriate choices in order to pursue these careers. Research in England has found low levels of awareness of the value of science courses and qualifications to a range of careers, and it seems very likely that similar lack of awareness is a factor in decision-making in Scotland also.

The aims of the national curricular guidelines are to ensure that all pupils study a broad and balanced curriculum during the compulsory stages of schooling, and this limits the dangers of premature specialisation. Nevertheless, the requirement for pupils to choose individual science subjects means that they are encouraged to specialise in physics, chemistry or biology within the science mode. When making their choices for Standard Grade it is relatively rare for pupils in state-funded schools to have the option of taking all three science subjects, and relatively common for them to drop all but one of the sciences. The need for pupils to choose between the sciences at an early stage of their education may be a contributory factor in low levels of participation in science. The current general science course is perceived to be an easy option for lower-attaining pupils, and consequently those with higher attainment and aspirations do not have the option of taking an integrated science course at Standard Grade which would lead on to specialisation at Higher Grade.

The current (general) science course is not a satisfactory option. In 2000 HMI reported that:

> *"Important weaknesses in Science courses included an over emphasis on worksheets, too little use of direct teaching, questioning and discussion, insufficient practical work and almost no homework. The slow pace of work in many classes prevented the coverage of the additional topics which would have enhanced the course. Most science courses focused on Foundation and General level work and, in many schools, Credit level work was not made available for abler pupils. In the best departments, staff worked hard to address these weaknesses and to give the course equal status with the separate sciences. It was widely recognised by many teachers that much of the content, examples and approaches in the Standard Grade Science course were dated and inappropriate".* (Scottish Executive, 2000b, p 10)

The subject divisions in Scottish science education compare unfavourably with the provision of a "double-award" science for GCSE in England and Wales which includes physics, chemistry and biology, but takes less time than would be needed should the pupil study all three sciences separately. Indeed a further proposal for the science curriculum by the QCA takes account of the two purposes of science education - to improve public understanding of science, as well as to increase the pool of science-qualified young people. It proposes that science education should be split into a number of modules:

- core modules, which would prepare pupils to be consumers, rather than producers of scientific knowledge, and which, taken together, would lead to a compulsory Single Award in science;
- applied and academic modules in a range of science options, which would bring the pupil up to a double award (or a triple award if they take all of the academic options in biology, physics and chemistry).

Physical science subjects (and mathematics) are seen as relatively difficult subjects. Schools are increasingly dividing up pupils in schools into different ability groups, or 'sets', so that high attaining pupils can be taught more difficult content at credit-level while less able pupils focus on easier work for Foundation or General courses. The practice of setting by ability encourages pupils to see perceive themselves as "good at maths and science" of "no good at maths and science", and this influences their future decision-making with respect to these subject areas.

A further issue is that in schools technology and science are separated - they occupy different modes of the curriculum, and technology is given lower priority than science. Science is a relatively high-status curricular area with a reputation for being difficult: this is borne out by the evidence that high-attaining pupils tend to study physics and chemistry. On the other hand, many of the technology subjects have inherited the relatively low-status of practical subjects such as metal work and woodwork which tended in the past to be studied by low attaining males. Technology courses at Standard Grade cover the full ability range, and provide pupils with understanding and skills which could complement those experienced in science courses.

As with science education, so with technology education, the challenge will be to educate all young people to think critically and creatively about the 'made' environment, as well as to educate the technologists and engineers of the future. The ability to evaluate technology, its' impact and effects, should have greater priority within the curriculum. Nevertheless, low uptake of school technology courses reduces their potential contribution to both aspects of the science strategy.

# CHAPTER 3: SCIENCE AND TECHNOLOGY IN POST-COMPULSORY SCHOOLING

The S5 and S6 stages of post-compulsory schooling provide opportunity for young people to specialise in the subjects they choose to study for national qualifications. This section looks first at levels of participation in the S5 and S6 stages at school, and then considers factors influencing study of science and technology courses during these stages. It considers the following questions:

- What proportion of young people stay on at school to S5 and S6? What are their reasons for staying on? To what extent does the pattern differ among young people who have gained credit-level Standard Grade awards in science and technology?
- Which science and technology courses are studied for National Qualifications in S5 and S6 by males and females?
- To what extent is participation in science and technology courses in S5/S6 influenced by subjects studied/achieved in S4?
- Do other background factors influence the choice to study science and technology in S5/S6?

## STAYING ON TO S5 AND S6

The end of compulsory schooling at approximately age 16 is an important transition point for young people. They must decide whether to stay at school or to leave and enter college or the labour market. An increasing proportion are choosing to stay-on at school (Howieson *et al.*, 2000). Over two thirds of the young people who completed S4 in 1998 stayed-on at school to the end of S5, and over half stayed-on at school to the end of S6 (Table 3.1).

**Table 3.1: Stage of leaving school by sex and Standard Grade attainment (% of young people who completed S4 in 1998)**

| | S4/winter S5 | End of S5 | End of S6 | *Unweighted N (=100%)* |
|---|---|---|---|---|
| **All** | **32** | **16** | **52** | ***4919*** |
| **Sex** | | | | |
| Female | 29 | 16 | 55 | *2834* |
| Male | 36 | 16 | 48 | *2085* |
| **S4 Standard Grade attainment point score** | | | | |
| Very low | 82 | 10 | 8 | *512* |
| Low | 48 | 26 | 26 | *752* |
| Medium | 22 | 19 | 59 | *1109* |
| High | 7 | 14 | 79 | *1287* |
| Very high | 1 | 9 | 90 | *1259* |
| **Credit level awards in science** | | | | |
| None | 54 | 19 | 27 | *2084* |
| One | 11 | 16 | 74 | *1286* |
| Two or more | 2 | 10 | 88 | *1549* |
| **Credit level awards in technology** | | | | |
| None | 40 | 17 | 43 | *3453* |
| One | 9 | 14 | 78 | *1251* |
| Two or more | 9 | 12 | 79 | *215* |

Females were a little more likely to stay-on at school than males, and young people with higher levels of S4 attainment were more likely to stay on than those with lower Standard Grade attainment.

Young people with credit level awards in science or technology subjects were more likely to stay-on at school than those who did not. 98% of young people who had gained two or more credit level awards in science stayed on to S5/S6, as did 91% of young people who had gained one or more awards in technology.

Of the young people who left school at the end of compulsory schooling, one quarter went to college full-time to study vocational qualifications including Scottish Vocational Qualifications (SVQ), City and Guilds, Royal Society for the Arts (RSA) and National Certificate modules. Just 4% of 16 year-old leavers studied SET (table not shown).

### Reasons for staying-on at school

The first sweep of the SSLS occurred when those who had stayed on at school were in the spring term of S5, and it asked young people their reasons for staying on at school; their responses are summarised in Table 3.2. Responses did not vary between males and females. Almost all of the young people indicated that they had stayed on to gain qualifications - to improve job prospects (96%), and to go on to further or higher education (90%). Most young people were also motivated by the desire to undertake certain courses or subjects (87%). For the majority of young people the decision to stay-on was easily made: 61% said that the idea of leaving had never crossed their mind. Just over half of young people indicated that one of the reasons for staying-on at school was their uncertainty about future careers. A minority of students gave more negative reasons for staying on, including the lack of available jobs or Skillseekers placements.

**Table 3.2: Reasons for starting post-compulsory schooling (% of young people at school in spring term of S5, 1998-99)**

| | Subjects in S5/S6 include: | | | | |
|---|---|---|---|---|---|
| | One science | Two sciences | Any technology | Maths | All S5 students |
| I thought that by getting better qualifications I'd improve my job prospects | 98 | 97 | 98 | 97 | 96 |
| I wanted qualifications for going on to further or higher education | 93 | 93 | 91 | 93 | 90 |
| There were certain courses or subjects I wanted to do | 88 | 89 | 90 | 89 | 87 |
| The idea of leaving after S4 never crossed my mind | 63 | 72 | 63 | 70 | 61 |
| I enjoyed school life | 61 | 62 | 57 | 62 | 60 |
| I hadn't decided on my future education or career | 52 | 47 | 50 | 49 | 52 |
| I was too young to leave at the end of S4 | 37 | 34 | 38 | 35 | 38 |
| I was too young to enter the job or training I'd chosen | 17 | 18 | 15 | 16 | 19 |
| There were no *Skillseekers* places available that I wanted | 10 | 9 | 10 | 9 | 10 |
| There were no jobs around that I wanted | 6 | 5 | 6 | 5 | 8 |
| I was too young to claim Social Security benefits | 2 | 1 | 3 | 2 | 4 |
| *Unweighted N (=100%)* | *1178* | *1067* | *973* | *2039* | *3237* |

The responses of young people who studied science, technology and mathematics in S5 were very similar to those of other S5 students. A larger proportion of those taking two or more science subjects, and/or mathematics, indicated that "the idea of leaving after S4 never crossed my mind" (respectively 72% and 70% compared with 61%). All other responses were broadly similar to the rest of the S5 student population.

### Attitudes to the future

A further set of question asked young people what they would like to do in the future; their responses are summarised in Table 3.3. S5 students were almost unanimous in wanting a full-time job which they enjoyed (98%), a career or profession (92%), and to have the full-time job throughout their adult life (92%). The majority would like to raise a family at some time in the future (89%), to get a qualification of some sort (78%) and to go to university and get a degree (76%). Almost two thirds of young people had a clear idea of the career they wanted (64%), while just one fifth said they would just wait and see (21%).

**Table 3.3: Attitudes to the future among S5 students (% of young people at school in spring-term S5)**

| | Subjects in S5/S6 include: | | | | |
|---|---|---|---|---|---|
| | One science | Two sciences | Any technology | Maths | All S5 students |
| In the future I would like to have a full-time job which I enjoy | 98 | 98 | 97 | 98 | 98 |
| Having a career or profession is important to me | 93 | 93 | 92 | 93 | 92 |
| I would like to have a full-time job for most of my adult life | 91 | 93 | 95 | 93 | 92 |
| I would like to raise a family some time in the future | 90 | 89 | 89 | 90 | 89 |
| I want to get some other qualifications of some sort | 80 | 74 | 76 | 76 | 78 |
| I would like to go to university and get a degree | 86 | 96 | 81 | 91 | 76 |
| I have a clear idea of the career that I want | 62 | 63 | 63 | 61 | 64 |
| I'll just wait and see where I end up | 22 | 22 | 22 | 21 | 21 |
| *Unweighted N (=100%)* | *1178* | *1067* | *973* | *2039* | *3237* |

There were hardly any differences in responses to these questions by young people who studied science, technology or maths in S5 compared with the whole S5 population. However, those studying two science subjects, and those taking mathematics were more likely than other students to say they would like to go to university (96% and 91% *vs* 76%).

There were very few differences between females and males in response to these questions (table not shown). A slightly greater proportion of females than males indicated that they had a clear idea of the career they wanted (67% *vs* 62%). However, more males than females said that they would like a full-time job throughout their adult life (95% *vs* 90%), and that they would like to raise a family some time in the future (91% *vs* 87%).

## COURSES AND QUALIFICATIONS IN S5 AND S6

The *Higher Still* reform of courses and national qualifications was first introduced in Scottish schools in session 1999-2000, with the first examination diet in 2000. Thus, Higher Still courses did not come on-stream until the year after members of the SSLS cohort entered S5. Those who continued into S6 in session 1999-2000 were among the first students to study Higher Still courses. In this transitional period respondents to the SSLS studied various qualifications:

| **S5** | **S6** |
|---|---|
| Highers | Certificate of Sixth Year Studies |
| National Certificate modules | Highers |
| Standard Grades | Intermediate 1 and 2 |

The main courses included in the results described in this report were Highers and Certificate of Sixth Year Studies. In subsequent years the Certificate of Sixth Year Studies has been replaced by Advanced Higher courses, but these were not available to the young people included in this study.

The analyses described in this report focus on the subjects studied rather than the qualifications attempted, and look at S5 and S6 overall rather than as separate stages. This is because increasing proportions of young people stay on for two years of post-compulsory schooling rather than leaving at the end of S5, and it is becoming very common for schools to provide Highers courses over two years, rather than as a “two-term dash”. Before the introduction of Higher Still schools used National Certificate modules as a means of certification of S5 achievement, and now use Intermediate qualifications for that purpose. This report looks at overall experience of science and technology over the two-year period.

## SCIENCE SUBJECTS STUDIED IN S5 AND S6

The transition to post-compulsory education provides young people with the opportunity to choose the subjects they wish to study, and drop those they do not. Of the young people who stayed on to post-compulsory schooling, almost a half (46%) chose to drop science completely in the post-compulsory stages. Females and males chose to drop science in more or less equal proportions (48% and 44% respectively).

**Table 3.4: Science subjects studied in S5 or S6 (% of females and males who completed spring term of S5)**

| | Females | Males | All |
|---|---|---|---|
| **Science subjects** | | | |
| Biology | 33 | 19 | 26 |
| Human Biology | 9 | 4 | 6 |
| Chemistry | 24 | 29 | 27 |
| Physics | 16 | 39 | 27 |
| At least one of the above science subjects | 52 | 56 | 54 |
| 2 or more individual science subjects | 23 | 27 | 25 |
| • Physics & Chemistry | 11 | 20 | 15 |
| • Biology & Chemistry | 14 | 10 | 12 |
| • Physics& Biology | 7 | 7 | 7 |
| 2 science subjects & mathematics | 20 | 24 | 22 |
| **Core subjects** | | | |
| Mathematics | 46 | 52 | 49 |
| English | 77 | 68 | 73 |
| *unweighted N (=100%)* | *2253* | *1612* | *3865* |

Just over half of all post-compulsory school students studied at least one science subject in S5 or S6; these are summarised in Table 3.4. Each of the science subjects, chemistry, physics and biology, was studied by about a quarter of the students in post-compulsory schooling. A small minority of students studied human biology. More females than males studied biology, and more males than females studied physics, but there was almost a gender balance among students studying chemistry.

A quarter of all post-compulsory students studied two or more science subjects, with physics and chemistry the most popular combination. It appears from Table 3.4 that all the students studying chemistry took the subject as part of a combination with either physics or biology. Almost all of the students who studied two or more science subjects in S5/S6 also studied mathematics.

## TECHNOLOGY SUBJECTS STUDIED IN S5 AND S6

As with science subjects, there was a drop in the overall proportion of young people who studied technology in post-compulsory schooling from half the cohort in S4 to one quarter of those who entered S5. Gender differences in participation increased, with just 13% of females compared with 41% of males studying any technology subjects in S5/S6. Computing was the most popular subject, studied by 7% of females and 19% of males (Table 3.5).

**Table 3.5: Technology subjects studied in S5 or S6 (% of females and males who completed spring term of S5)**

| | Females | Males | All |
|---|---|---|---|
| **Technology subjects** | | | |
| Technological Studies | <1 | 6 | 3 |
| Craft and Design | 4 | 14 | 9 |
| Graphic Communication | 3 | 11 | 7 |
| Computing | 7 | 19 | 13 |
| At least one of the above technology subjects | 13 | 41 | 26 |
| 2 or more technology subjects | 1 | 8 | 4 |
| *unweighted N (=100%)* | *2253* | *1612* | *3865* |

## FACTORS INFLUENCING SCIENCE AND TECHNOLOGY SUBJECTS STUDIED IN S5 OR S6

The factors influencing participation in science and technology subjects were analysed using a series of multilevel statistical models that allow us to estimate the effect of each factor while controlling for all other factors. Detailed results are given in Appendix Table 4&5. The factors influencing the science and technology subjects studied in S5 or S6 are:

- whether the young person had studied the subject in S4, and attainment in the subject;
- the number of science or technology subjects studied and attained in S4;
- mean award at Standard Grade (averaged over all subjects attempted);
- attainment in Mathematics at Standard Grade;
- sex;
- whether has university aspirations;
- whether has clear career intentions;
- school type.

A number of other variables were tested in the statistical models, but were found not to be significant after controlling for the factors outlined above; they included parents' education and occupation, family structure, home ownership, local area deprivation and average school characteristics. Alternative measures of S4 attainment were tested, including an overall point score, but they provided weaker explanation of variance than those outlined above.

### S4 studied/attainment in the subject

The key factor influencing the science and technology subjects studied in S5 or S6 was whether the young person had studied the subject successfully in S4[3]. Young people entering S5 are generally required to have a credit-level award in a subject at Standard Grade before they are allowed to attempt it at Higher Grade.[4] Consequently, the strongest predictor of studying the science or technology subject in S5/S6 was if the young person had gained a credit level award in that subject at Standard Grade. This reinforces the importance of subject choices for Standard Grade which determine subsequent curricular pathways.

[3] Very few young people attempted science subjects in S5/S6 if they had not previously studied them in S4: just 2% of the young people who did not study chemistry in S4 studied chemistry in S5/ S6, and similarly 3% of those who did not study physics in S4 took physics in S5/S6. There was a slightly greater likelihood of studying biology for the first time in S5/S6; of those who did not take biology in S4 8% took biology, and 3% took human biology in S5/S6.

[4] More flexibility is allowed at S6, so that occasionally students attempt Higher Grade in subjects they have not previously studied.

### The number of science or technology subjects studied/attained at Standard Grade

The number of science subjects studied indicates the priority given to science or technology at Standard Grade. In addition, studying more than one science or technology subjects at Standard Grade is likely to reinforce the appropriate skills of analysis, data handling, IT and numeracy so that young people who have studied more than one science or technology subject are more confident in their ability to study these subjects in future.

Young people who had studied more than one science subject in S4 were more likely to study chemistry or biology than those who had studied just one science at S4. Young people who had gained more than one credit-level award in science were more likely to study physics, biology or human biology than those who had gained just one (or none). However the number of additional credit-level awards in science did not make a difference to the likelihood of studying chemistry.

Similarly, participation in technology subjects in S5/S6 was influenced by the number of technology subjects studied in S4 - those who had studied more than one technology subject at S4 were more likely to study technological activities, craft and design and graphic communication, but there was no effect on computing. There was also an effect of the number of science awards at credit level - young people were more likely to study technological studies, and less likely to study craft and design if they had one or more credit-level awards in science subjects.

### Mean award at Standard Grade

A number of measures of overall attainment at Standard Grade were tested in the model, and of these “mean award” provided the greatest explanatory power. Mean award is derived from the average results of all the Standard Grade examinations attempted by the student in S4. This measure is similar to the “grade point average” which is used by many schools as a predictor of Higher Grade potential among students. There was no evidence that study of biology or human biology was influenced by mean Standard Grade awards. However, young people who had gained high mean Standard Grade awards were more likely than their peers to study chemistry and physics in S5/S6. This tends to confirm that physics and chemistry are perceived as relatively difficult subjects, best suited to high-attaining students. Young people lacking confidence in their own ability may perceive that physics and chemistry are too difficult for them, and therefore choose easier options.

Average Standard Grade score did not influence participation in technology subjects when all other factors were taken into account.

### Attainment in mathematics at Standard Grade

Students who gained a general award in mathematics at Standard Grade were less likely than their peers to study chemistry in S5/S6, but students who gained a credit award were more likely to study physics in S5/S6.The positive relationship between physics and credit-level mathematics confirm the links between these two subjects. The negative relationship between chemistry and general award at mathematics suggest that students who were not strong enough in mathematics to gain a credit award were less likely to study chemistry than their peers. This finding reinforces the view that physics (and to a lesser extent chemistry) requires strong mathematical skills. Students who perceive that they are not good at mathematics may be reluctant to study physics and chemistry as a consequence.

Young people with credit-level mathematics were less likely to take craft and design in S5/S6.

### Sex

After taking account of gender differences in participation and attainment at S4, there was a further gender gap in participation in chemistry and physics in S5/S6. All other things being equal, males were more likely to study chemistry and physics in S5/S6 than females. In addition, males were more likely than females to study each of the technology subjects. Gender inequality in participation in science and technology has been perceived as an issue of concern for a number of years (Tinklin *et al.*, 2001). Efforts to increase participation and attainment in science and technology by girls in the compulsory stages have been relatively successful, but young women still choose not to study physical science and technology at the post-compulsory stages.

### University aspirations and career intentions

Students who agreed that they would like to go to university and get a degree were more likely than students who did not have university aspirations to study each of the science subjects in S5/S6. It seems likely that students who aspire to university believe that science subjects provide important entrance qualifications. In addition, young people who agreed with the statement "I have a clear idea of the career that I want" were more likely to study physics than those who did not agree with the statement. The other science subjects were not influenced by career intentions. It may be that students who aspire to scientific careers are more likely to have clear career intentions, and therefore are more likely to perceive that physics is an important entrance qualification.

Young people aspiring to go to university were more likely to study computing than those who did not, but university aspirations did not influence study of the other technology subjects.

### School type

After taking all other factors into account, students attending independent schools were less likely to study chemistry and computing than their peers at state-funded schools. There was no difference by school type in levels of participation in other science and technology subjects when all other factors were taken into account.

### School differences

There was significant variation between schools in levels of participation in each of the science and technology subjects. Such variation is probably related to differences between schools in staffing and resources.

## ATTAINMENT IN SCIENCE AND TECHNOLOGY BY THE END OF POST-COMPULSORY SCHOOLING

For this study the measure of attainment derived from the SQA data is based on 'passes' at Higher Grade (awards at A-C). Higher Grade is the qualification recognized for entry to higher education, and although some members of the SSLS cohort studied CSYS in S6, they would have been required to obtain a pass at Higher Grade before commencing CSYS. Therefore, summarising attainment in science and technology in terms of Higher Grade provides a straightforward means of comparison between subjects. Table 3.6 summarises attainment at Higher Grade A-C in science and technology by the end of S6.

**Table 3.6: Attainment at Higher Grade A-C or better in S5 or S6 (% of females and males who completed spring term of S5)**

| | Females | Males | All |
|---|---|---|---|
| **Science subjects** | | | |
| Biology | 22 | 13 | 18 |
| Human Biology | 6 | 3 | 4 |
| Chemistry | 19 | 23 | 21 |
| Physics | 13 | 29 | 21 |
| At least one of the above science subjects | 37 | 41 | 39 |
| 2 or more individual science subjects | 17 | 21 | 19 |
| • Physics & Chemistry | 9 | 16 | 12 |
| • Biology & Chemistry | 11 | 8 | 9 |
| • Physics& Biology | 5 | 6 | 5 |
| **Technology subjects** | | | |
| Technological Studies | <1 | 4 | 2 |
| Craft and Design | 3 | 9 | 6 |
| Graphic Communication | 2 | 8 | 5 |
| Computing | 5 | 13 | 9 |
| At least one of the above technology subjects | 9 | 28 | 18 |
| 2 or more technology subjects | 1 | 5 | 3 |
| **Core subjects** | | | |
| Mathematics | 35 | 39 | 37 |
| English | 61 | 51 | 56 |
| **Combinations** | | | |
| Mathematics with 2+ science | 15 | 20 | 17 |
| Mathematics with 2+ science and at least one technology subject | 2 | 7 | 4 |
| *unweighted N (=100%)* | *2253* | *1612* | *3865* |

By the end of post-compulsory schooling 39% of students had achieved a Higher Grade pass in at least one science subject, and 19% had achieved two or more passes in science. Slightly more males than females had gained Higher Grade passes in sciences, and this was the result of gender differences in participation shown by Table 3.1. Some 18% of young people achieved at least one Higher Grade pass in a technology subject, with three times as many males as females studying and achieving an award in technology. Just over a third of students (37%) achieved Higher Grade passes in mathematics, and the proportion of males gaining awards was slightly higher than that of females. A very small minority (4%) of students had achieved Higher Grade passes in science, maths and technology.

## SUMMARY

### Staying-on at school to S5

Two-thirds of young people who completed S4 in summer 1998 stayed-on to post-compulsory schooling. Their principal reason for staying on was to gain qualifications that would lead to better careers.

The majority of young people (89%) who had gained credit-level awards in science or technology at Standard Grade stayed on for S5, and over three-quarters stayed on for S6.

### Courses in S5/S6

In S5 and S6 young people could choose the subjects they wished to study; half of S5/S6 students studied at least one science subject and one quarter studied two or more science subjects:

- 27% studied chemistry (and 21% achieved Higher Grade A-C);

- 32% studied biology or human biology (and 22% achieved Higher Grade A-C);
- 27% studied physics (and 21% achieved Higher Grade A-C).

Almost all students who studied chemistry took it in conjunction with another science subject - either physics or biology. The majority of students who studied two or more science subjects also studied mathematics.

A quarter of all S5/S6 students studied at least one technology subject:

- 13% studied computing (and 9% achieved Higher Grade A-C);
- 9% studied craft and design (and 6% achieved Higher Grade A-C);
- 7% studied graphic communication (and 5% achieved Higher Grade A-C);
- 3% studied technological studies (and 2% achieved Higher Grade A-C).

The factors influencing the science and technology subjects studied in S5 or S6 are:

- whether the young person had studied the subject in S4, and attainment in the subject;
- the number of science or technology subjects studied and attained in S4;
- mean award at Standard Grade (averaged over all subjects attempted);
- attainment in Mathematics at Standard Grade;
- sex;
- whether has university aspirations;
- whether has clear career intentions;
- school type.

## ISSUES RAISED BY THE RESEARCH

The main issue for this study is that almost half of young people in S5 and S6 do not study any science subjects and three-quarters do not study technology. Policies to raise participation in SET need to address this shortfall.

Gender differences are clearly a major issue for participation in technology. Very few females study technology in S5 and S6.

Standard Grade subject choices were a key factor influencing the choice of subjects to be studied in S5 and S6. Very few students took science and technology subjects in S5 or S6 if they had not previously studied the subject at Standard Grade. This reinforces the importance of ensuring that the choices made for Standard Grade keep open the option of study in post-compulsory education. The current lack of an integrated-science option at Standard Grade and Higher may provide a barrier to participation.

The pool of young people in S5 who had achieved credit level awards in science, technology and mathematics at Standard Grade is relatively large:

- 63% of students have one or more credit-level awards in science subjects, but just 54% studied any sciences in S5/S6;
- 33% of students have one or more credit-level awards in technology subjects, but just 26% studied any technology in S5/S6;
- 48% of students have credit-level awards in mathematics, and 49% studied mathematics in S5/S6.

Why do students with credit level awards in science and technology choose not to continue these subjects in S5 and S6?

Part of the explanation may lie in perceptions that physical science subjects are difficult and need mathematical skills. Consequently these subjects were attempted by the highest attaining pupils and those with credit-level mathematics. However, although science subjects may be perceived to be relatively more difficult, this may be because they draw on different learning skills than other subjects. The SQA aims to maintain the same level of difficulty across all subjects within a particular level of qualifications (whether Standard Grades, Highers or any other type of qualification), and has rigorous processes to ensure that a parity exists between the capability requirements for different subjects (SQA: personal communication).

Nevertheless, young people's perceptions of the relative difficulty of subjects are an important issue for their subject choices. Since the over-riding aim of young people staying-on to post-compulsory schooling is to achieve qualifications, less-confident students may decide to avoid difficult subjects in which they have more chance of failure. Decisions to opt for safe choices may be reinforced by schools for whom performance targets and league tables are defined in terms of overall levels of achievement.

Raising young people's confidence in their ability to study science and technology may be achieved by ensuring that pupils have more opportunity to study science and technology at earlier stages of education, following the implementation of national guidelines for the 5-14 stages (see section 2).

Young people who studied more than one science or technology subject at Standard Grade were a great deal more likely to study these subjects at S5 and S6. It is likely that by studying more than one science these young people developed appropriate scientific skills to a greater extent than pupils who studied just one science or technology subject, and they developed more confidence in their ability to study these subjects in future. Consequently, if more pupils could be encouraged to study more than one science or technology subject at Standard Grade, more young people are likely to develop the confidence to study science and technology at the post-compulsory stages.

The benefits of studying science and technology need to be highlighted for young people if levels of participation are to be increased. Young people need to be aware that qualifications in science may increase the range of potential career opportunities because the skills developed through studying science, including analytical skills, data analysis, IT skills and numeracy, are sought after in many different careers (Munro & Elsom, 2000). As part of the *Science Strategy for Scotland* the Scottish Executive has asked Careers Scotland to ensure that there is good quality, unbiased information and advice about education and career opportunities in science (Scottish Executive, 2001b). However, information alone is not sufficient, and young people need support in developing their career plans and making appropriate subject choices at earlier stages of their education, including primary stages (Howieson & Semple, 2002).

# CHAPTER 4: COURSES, QUALIFICATIONS AND OTHER ACTIVITIES AT AGE 18-19

The second sweep of the SSLS took place in spring 2001 when members of the cohort were aged 18-19 and all had left school. This section focuses on their transitions from school to post-school destinations by the time of the second sweep. It considers the following questions:

- What were the main activities of young people at age 18-19, and what were the main activities of young people who had gained higher-grade awards in science and technology?
- What proportion of young people entered education courses at age 18-19?
- What proportion of young people entered degree courses, and other advanced courses?
- What factors influenced participation in higher education by age 18-19?

## MAIN ACTIVITIES AT AGE 18-19

The main activities in spring 2001 of the whole cohort are summarised in Table 4.1. At that stage just over half of the cohort were in the labour market. Just over a quarter of young people reported that they were in full-time work that did *not* include government-supported training. A further 14% of young people were in jobs that included government supported training (ie Modern Apprenticeships, Skillseekers or New Deal placements), but this activity was heavily skewed towards males. A small proportion of young people were unemployed or in part-time work. (See Howieson *et al* 2001 for further analysis of entry to the labour market). Some 44% of young people were in full-time education at the age of 18-19.

**Table 4.1: Whole cohort: Main activity at age 18-19, by sex (%)**

| | Females | Males | All cohort |
|---|---|---|---|
| **Labour Market** | | | |
| Job without government training | 29 | 26 | 27 |
| Job with Modern Apprenticeship, Skillseekers or New Deal | 6 | 22 | 14 |
| Part-time work | 4 | 2 | 3 |
| Out of work | 6 | 9 | 8 |
| **Full-time Education** | | | |
| Higher education | 41 | 34 | 37 |
| Other education | 8 | 7 | 7 |
| **Other** | 5 | 2 | 4 |
| *Unweighted N (=100%)* | *2834* | *2085* | *4919* |

### Main activities of young people with Higher Grade in science, maths or technology

Young people who had gained Higher Grade awards in science, mathematics or technology were less likely to enter the labour market than other members of the cohort (Table 4.2). However, this is probably less to do with their science qualifications, and more because higher-qualified young people generally were less likely to enter the labour market. Jobs without government-supported training were the most common labour-market destination.

It is possible that some of the science-qualified young people who entered the labour-market at age 18-19 were taking a "year out" before going to university. The survey asked young workers about their perceptions of the work they were currently doing. Young people with two or more Higher Grade awards in science were much less likely than other young workers to agree "This is the kind of work I want to do in the future" (14% *vs*. 51%). They were also more likely to agree "The *main* reason I do this is for the money" (82% vs 60%).

A very high proportion of science qualified young people entered full-time education. 89% of those with two or more Higher Grade awards in science, 85% of those with Higher Grade mathematics, and 75% of young people with one or more awards in technology entered full-time courses.

**Table 4.2: Science qualified young people: Main activity in spring 2001 by number of Higher Grade awards in science, maths and technology (%)**

| | Science subjects | | Maths | Technology | All cohort |
|---|---|---|---|---|---|
| | One | Two or more | | One or more | |
| **Labour Market** | | | | | |
| Job without government training | 12 | 6 | 9 | 14 | 27 |
| Job with Modern Apprenticeship, Skillseekers or New Deal | 3 | 1 | 2 | 7 | 14 |
| Part-time work | 2 | 1 | 2 | 2 | 3 |
| Out of work | 1 | 1 | 1 | 2 | 8 |
| **Full-time Education** | | | | | |
| Higher education | 71 | 83 | 79 | 68 | 37 |
| Other education | 7 | 6 | 6 | 7 | 7 |
| **Other** | 3 | 2 | 2 | 1 | 4 |
| *Unweighted N (=100%)* | *851* | *823* | *1601* | *729* | *4919* |

## COURSES AND QUALIFICATIONS AT UNIVERSITY AND COLLEGE

In spring 2001, at age 18-19, half of the SSLS cohort of young people were studying courses at college or university. The majority were taking full-time courses, but a small minority (6% of the cohort) were studying part-time. Almost a third of the cohort (29%) were studying degree-level courses, while smaller proportions of young people studied HNC/HND or non-advanced courses.

**Table 4.3: Courses and qualifications being studied in spring 2001 (% of females and males)**

| | Females | Males | All cohort |
|---|---|---|---|
| **Full-time courses** | | | |
| Degree | 31 | 28 | 29 |
| HNC/HND | 8 | 6 | 7 |
| Non-advanced | 10 | 6 | 8 |
| **Part-time course** | 4 | 9 | 6 |
| No course | 47 | 51 | 49 |
| *Unweighted N (=100%)* | *2825* | *2074* | *4899* |

The reasons given for taking these courses are summarised in Table 4.4. The vast majority of students agreed that they were doing their current courses so that they could get a satisfying job in the future, and because they were particularly interested in the subjects they were studying. The fact that these two responses were given by such an overwhelming proportion of students suggests that the intrinsic motivation of satisfaction and interest is paramount. The majority of students also expressed the perception that qualifications were needed to get a well-paid job. Students taking all levels of course were broadly similar in expressing the first three reasons, but degree-level students were more likely than other students to agree that their course was the 'next step' in terms of progression towards their future career.

**Table 4.4: Reasons for studying course in spring 2001 by level of qualification attempted (% of students who agreed with each statement)**

| | Degree | HNC/HND | Non-advanced | All students |
|---|---|---|---|---|
| I am doing this course... | | | | |
| ...so that I can get a satisfying job in the future. | 96 | 90 | 88 | 93 |
| ...because I am particularly interested in the subject(s). | 93 | 94 | 88 | 92 |
| ...so that I can get a well-paid job in the future. | 89 | 82 | 80 | 85 |
| ...because it was the 'next step' for me after school/ college. | 86 | 77 | 58 | 77 |
| ...because I could not get a job. | 1 | 2 | 5 | 2 |
| *Unweighted N (=100%)* | *1847* | *401* | *663* | *2911* |

## FACTORS INFLUENCING PARTICIPATION IN HIGHER EDUCATION COURSES

The factors influencing participation in full-time advanced courses were analysed using a series of multilevel logistic regression models that looked at degree-level courses, HNC/HND courses and both levels of advanced course combined. The results are detailed in Appendix Table 6, and show differences by:

- whether the young person stayed at school for S5/S6;
- number of Higher Grade awards at A-C;
- number of Higher Grade awards at A;
- number of science or technology subjects studied in S5/S6;
- number of awards at Higher Grade in science subjects;
- sex;
- mother's education;
- parents' occupation;
- home ownership;
- school type.

### School S5/S6

Young people who stayed at school to S5 were more likely to enter degree-level courses by age 18-19 than those who left school at the end of compulsory schooling. However, entry to HNC or HND courses was not dependent on having stayed at school to S5, and this suggests that these courses were entered by young people who had gone to college rather than staying at school for S5/S6.

### Higher Grade attainment

Entry to degree-level courses is dependent on Higher Grade attainment; the number of Higher Grade awards at A-C and also the number of awards at A were strong predictors of entry to degree-level courses. However, there was no evidence that entry to HNC/HND courses was dependent on overall Higher Grade attainment. On the contrary, young people with Higher Grade awards at A were less likely than other to enter HNC/HND courses. Clearly, HNC/HND courses cater for students with lower levels of Higher Grade qualification than degree-level courses.

### Attainment in science and technology

Young people who had achieved one or more Higher Grade awards in science subjects were more likely to enter degree-level courses than those who had no science awards at Higher

Grade. This effect is found after controlling for overall levels of Higher Grade attainment, and suggests that science-qualified young people have a greater chance of entering degree-level courses than those who are not science qualified. Attainment in technology subjects did not have an effect on entry to degree-level courses.

On the other hand, young people with one or more Higher grade award in science were less likely than others to study HNC or HND courses, but young people who had studied science or technology in S5 or S6 without achieving Higher Grade were more likely to study HNC/HND.

**Sex**

There is no evidence of difference in entry to degree-level courses between males and females after controlling for Higher Grade qualifications in science. However, an alternative model that does not control for science qualifications shows that males are more likely to enter degree-level courses than females with the same level of overall Higher Grade attainment. This suggests that the advantage accruing to science-qualified young people, and the greater proportion of males than females with science qualifications, boosts the numbers of males in degree-level courses.

All other things being equal, females are more likely than males to study HNC/HND courses. These results suggest that there may be continuing gender inequality in entry to higher education courses because females enter lower-level courses than males with the same levels of attainment.

**Family background**

There are differences in entry to advanced courses between young people from advantaged and disadvantaged family backgrounds even after controlling for Higher Grade attainment. On average, young people were more likely to enter degree-level courses if their mother had some post-compulsory education, if their father's occupation was professional or intermediate, and if the family home was owner-occupied. (However, the interaction term "total HG awards x father professional/intermediate" suggests that other young people with very high levels of attainment gained entry to degree-level courses without the benefit of a professional father).

Having a mother in a professional/intermediate or other non-manual occupation was associated with a greater chance of entry to HNC/HND courses. Overall levels of entry to advanced courses were lower among young people with mother in an unskilled occupation than among those with mothers in non-manual or skilled manual occupations.

These findings confirm the continuing inequality in entry to higher-education courses by social class background described by Forsyth and Furlong (2000), who found that because of financial difficulties young people from disadvantaged backgrounds were likely to enter shorter, lower-status courses and institutions than young people from more advantaged backgrounds.

**School type**

Independent schools provide an advantage with respect to entry to degree-level courses. Young people from independent schools were much more likely to enter degree-level courses and less likely to enter HNC/HND courses than young people with the same attainment from state-funded schools. (However, the interaction term "Total HG awards x independent schools" suggests that other young people with very high levels of attainment gained entry to degree-level courses without the benefit of attending an independent school).

### School differences

After controlling for all the factors in the models there was no evidence of difference between schools in entry to degree-level or HNC/HND courses, but there were small differences in overall levels of participation in advanced courses.

## SUMMARY

In spring 2001, when the SSLS cohort were surveyed for at age 18-19, just over half of young people were in the labour market, 44% of young people were in full-time education at college or university.

A very high proportion of science/technology - qualified young people had entered full-time education by age 18-19 (89% of those with two or more Higher Grade awards in science).

Almost one third of all young people at 18-19 were studying full-time degree-level courses, and 7% were taking other advanced courses.

The vast majority of students agreed that they were taking their courses so that they could get a satisfying job in future and because they were particularly interested in the subjects they were studying.

Factors influencing participation in higher education courses were:

- whether the young person stayed at school for S5/S6;
- number of Higher Grade awards at A-C;
- number of Higher Grade awards at A;
- number of science or technology subjects studied in S5/S6;
- number of awards at Higher Grade in science subjects;
- sex;
- mother's education;
- parents' occupation;
- home ownership;
- school type.

## ISSUES ARISING FROM THE RESEARCH

Although Higher-Grade attainment is the key determinant of entry to higher education, young people with science qualifications had a greater chance of entering degree-level courses than those with the same overall Higher Grade achievement who were not science qualified. There is thus advantage associated with science qualifications.

At present females are less likely to gain science qualifications than males because of their low levels of participation in science subjects at school. Consequently, females are relatively disadvantaged in entry to degree-courses compared with males of the same overall Higher Grade achievement.

There is additional inequality in entry to higher education associated with family background. Young people from professional/intermediate backgrounds were more likely to enter degree-level courses than their peers with the same Higher Grade achievement. Similarly, those from independent schools had a greater chance of entering degree-level courses than their peers from state schools with the same Higher Grade achievement.

Differences in status of degree-level courses compared with HNC/HND courses are associated with social inequality. Young people from disadvantaged backgrounds are more likely to enter HNC/HND courses than young people from more advantaged backgrounds.

# CHAPTER 5: ADVANCED COURSES IN SCIENCE, ENGINEERING AND TECHNOLOGY (SET)

The specialist training of scientists, engineers, technologists and technicians in higher education is very important for achieving the aims of the *Science Strategy* to produce the scientists of tomorrow, and also for producing the future teachers of science and technology (Scottish Executive, 2001b). This section focuses on the subject courses young people were studying at college and university in 2001. It considers the following questions:

- What proportion of males and females studied SET courses at degree-level, HNC/HND, and non-advanced level?
- What factors influenced the study of SET among students in higher education?
- What proportion of higher education students with qualifications in science and technology were studying SET, and what proportion were taking other subjects?

## PARTICIPATION IN SET

Courses in SET were a substantial category of degree-level courses, and were studied by one third of all students studying at degree level (Table 5.1). There were marked gender differences in participation, with almost half of male degree-level students taking SET, compared to one fifth of female degree-level students. Mathematical sciences and informatics (which includes computing), and engineering and technology attracted more degree-level students than biological or physical sciences.

**Table 5.1: SET courses by level studied by young people who were studying full-time in spring 2001 (% of females and males studying each level)**

| | Females | Males | All |
|---|---|---|---|
| **Degree** | | | |
| Biological sciences | 7 | 4 | 6 |
| Physical sciences | 6 | 9 | 7 |
| Mathematical sciences and informatics | 6 | 16 | 11 |
| Engineering and technology | 2 | 17 | 9 |
| **All SET** | **21** | **46** | **33** |
| *Unweighted N (=100%)* | *1068* | *785* | *1853* |
| **HNC/HND** | | | |
| Biological sciences | 2 | 1 | 1 |
| Physical sciences | 1 | 0 | <1 |
| Mathematical sciences and informatics | 3 | 21 | 10 |
| Engineering and technology | 0 | 17 | 8 |
| **All SET** | **6** | **39** | **20** |
| *Unweighted N (=100%)* | *250* | *155* | *405* |
| **Non-advanced** | | | |
| Biological sciences | 3 | 2 | 2 |
| Physical sciences | 2 | 3 | 2 |
| Mathematical sciences and informatics | 5 | 15 | 9 |
| Engineering and technology | <1 | 15 | 6 |
| **All SET** | **10** | **35** | **19** |
| *Unweighted N (=100%)* | *260* | *120* | *380* |

Among degree-level courses, computing and information science has been the biggest growth area in recent years: the Scottish Higher Education Funding Council (SHEFC) reports that between 1996-7 and 2001-2 the numbers of full-time equivalent students eligible for funding by SHEFC increased by 3.5% overall, but numbers in computing and information science increased by 45.5%, and in mathematics and statistics by 4.1%, whereas in science numbers increased by 1.6% and numbers in engineering and technology declined by 5.6% (Scottish Higher Education Funding Council, 2002).

Sub-degree level courses cater for students with lower qualifications, and are particularly important for training at technician level. However, Table 5.1 shows that SET courses attracted a smaller proportion of students taking HNC/HND than students taking degrees. Just one fifth of HNC/HND students studied SET courses, and there were strong gender differences in participation; 39% of males and just 6% of females taking HNC/HND studied SET. A similar pattern of participation is found among students taking non-advanced courses.

## FACTORS INFLUENCING STUDY OF SET AMONG STUDENTS IN HIGHER EDUCATION

This section is based on students in higher education taking degree or HNC/HND courses. The factors were analysed using a series of multilevel statistical models which estimated the "net" effect of each variable after taking account of all other variables (details are in the Appendix Table 7) Significant factors included:

- level of course;
- Higher Grade passes in specific subjects;
- numbers of science and technology subjects studied in S3/4, S5/6 and awards at Higher Grade;
- overall Higher Grade attainment;
- sex;
- family background.

### Level of course

Using the statistical models we can compare the likelihood of participants in HNC/HND courses studying SET with that of students in degree courses, after taking account of their different levels of attainment and other characteristics. The results confirm that after taking account of all other factors students who were taking HNC or HND courses were less likely to be studying SET courses than students taking degree-level courses. Specifically, students who were taking HNC or HND courses were less likely to be studying physical science courses than students taking degree-level courses. However, there was no evidence of difference between degree-level and HNC/HND students in the probability of studying biological sciences, mathematics and informatics or engineering science when all other factors were taken into account.

### Higher Grade passes in specific subjects

The subjects in which young people had gained Higher Grade passes were a key predictor of the courses they studied in higher education.

- Young people with Higher Grade passes in biology were more likely to study biological sciences, and less likely to study mathematics and informatics or engineering technology than those who did not achieve Higher Grade biology.
- Young people with Higher Grade chemistry were also more likely to study biological science, but there was no evidence that attainment of Higher Grade chemistry predicted participation in other science courses.
- Young people who had achieved Higher Grade physics were more likely than their peers to study SET. Higher Grade physics influenced the study of physical science and engineering technology.
- A pass in Higher Grade mathematics predicted the study of mathematics and informatics, and also influenced overall probability of participation in SET.

- Young people with a Higher Grade pass in technological studies, craft and design or graphic communication were more likely to study engineering technology, and these subjects also influenced overall likelihood of studying SET courses.
- Those with Higher Grade computing were more likely to study mathematics and informatics, and less likely to study engineering technology. Computing Higher Grade also increased overall likelihood of studying SET courses.
- Young people who attained Higher Grade English were less likely than their peers to study mathematics and informatics, but equally likely to study other SET courses.

**Numbers of science and technology subjects studied in S3/4, S5/6 and awards at Higher Grade**

The number of science and technology subjects studied in S3/S4 and in S5/S6 is an indication of the extent to which young people were specialising in SET during their school career. Young people who took more than one science and/or technology subject in S3/S4 were more likely than their peers to study engineering technology in higher education. Those who took one or more science subjects in S5/S6 were more likely to study biological or physical science in higher education, and also more likely to study a SET course overall. The more Higher Grade passes in science that a student had attained, the more likely s/he was to study biological science, mathematics and informatics and SET overall. However, there was no evidence the number of technology subjects studied or achieved in S5/S6 made a difference to the probability of studying SET courses in higher education.

**Overall Higher Grade attainment**

Study of SET in higher education was associated with lower overall Higher Grade attainment. All other things being equal, students with a large number of Higher Grade passes were less likely to study SET courses than students with lower Higher Grade attainment. Similarly, students with a number of Higher Grade awards at A were less likely to study SET overall, and less likely to study biological science. Part of the explanation for these finding may be that high-attaining students with qualifications in science may opt to study medicine and dentistry rather than SET. In addition, these findings suggest that the entry requirements for SET courses may be less stringent than those for other courses.

**Sex**

After taking account of all other factors, males were more likely than females to be studying SET courses, and specifically they were more likely to be studying mathematics and informatics, or engineering science. There was no evidence of gender differences in participation in biological or physical sciences when other factors are controlled for.

The interaction terms with sex suggest that the gender gap in overall participation in SET in HNC/HND courses is greater than the gender gap in degree courses. However, the gender gap in mathematics and informatics is smaller among students who have achieved Higher Grade mathematics than among those who have not, and the overall participation in SET courses is more gender-balanced among students with two or more Higher Grade awards in science.

**Family background**

After taking account of all the factors described above there was evidence that young people from lone-parent backgrounds were more likely to study SET in higher education than those who did not have lone parents, and specifically were more likely to study mathematics and informatics. It is not clear why the children of lone parents have a greater probability of studying SET, except for evidence from an earlier study (Howieson *et al.*, 1993) that young people from lone-parent families are more dependent than other pupils on advice about careers from careers officers and teachers. We might also speculate that the perceived availability of well-paid jobs in the IT sector holds greater attraction for the children of lone-parents because of the problems of student finance.

We have noted above that family background influences whether young people enter higher education, and the level of course studied. There was no evidence that participation in SET in higher education was further influenced by family background, or school background, when overall attainment and subject-specific attainment was taken into account.

### A cohort perspective

If we look at the cohort as a whole, we find that 11% were studying advanced courses in SET at age 18-19. There was a continuing influence of science subjects studied for Standard Grade at age 14-15; 24% of young people who studied two or more science subjects at Standard Grade went on to study SET in higher education compared with just 5% of those who studied one science at Standard Grade.

### Other influences

The SSLS is a general-purpose survey, and does not have detailed information about young people's reasons for choosing to study SET in higher education. However, the Roberts' Review has identified a number of factors influencing declining levels of participation in engineering and physical sciences in the UK:

- mismatches between school-level physical sciences and mathematics courses and undergraduate courses in related subjects (which prevent some students making the transition to higher education smoothly);
- the length and perceived difficulty of science and engineering degrees - in particular, the extent to which four-year degrees and more structured study in many science and engineering courses act as a disincentive to studying these courses;
- the legacy of under-investment in universities' teaching laboratories, which has resulted in around half the teaching facilities in universities being judged unsatisfactory;
- the lack of adequate information for science and engineering students on employment opportunities and postgraduate study options;
- the apparent mismatch between the mix of skills and aptitudes possessed by SET graduates and those needed by business (HM Treasury, 2002, section 3.)

The Roberts Review also discusses issues arising from the student funding system that creates student debt burdens which may cause added difficulty in studying science and engineering subjects.

## OTHER ADVANCED COURSES ENTERED BY SCIENCE-QUALIFIED YOUNG PEOPLE

The range of courses studied in higher education by students who had gained Higher Grade awards in science, mathematics and technology is summarised in Table 5.2. There are distinctive differences in courses followed by students who had gained two or more Higher Grade awards in science subjects, one or more subjects in technology, or a Higher Grade award in mathematics. However, students with just one Higher Grade award in science did not differ from the average for all higher education students.

**Table 5.2: Advanced courses studied in spring 2001 by number of Higher Grade awards in science, mathematics and technology (% of students studying advanced courses)**

| | Higher Grade | | | | All in HE |
|---|---|---|---|---|---|
| | Science | | Maths | Technology | |
| | One | Two or more | | One or more | |
| **SET** | | | | | |
| Biological science | 2 | 13 | 7 | 2 | 5 |
| Physical science | 7 | 11 | 8 | 5 | 6 |
| Mathematics and Informatics | 10 | 12 | 13 | 24 | 11 |
| Engineering technology | 12 | 12 | 12 | 21 | 10 |
| **Other** | | | | | |
| Medicine & dentistry | <1 | 6 | 3 | 1 | 2 |
| Subjects allied to medicine | 10 | 18 | 13 | 5 | 11 |
| Agriculture & related subjects | 1 | 3 | 2 | 1 | 2 |
| Architecture, building & planning | 4 | 2 | 3 | 6 | 3 |
| Social studies | 11 | 7 | 10 | 6 | 11 |
| Business & administration | 18 | 7 | 15 | 12 | 16 |
| Mass communication & documentation | 6 | 1 | 2 | 5 | 7 |
| Language & related disciplines | 6 | 4 | 5 | 1 | 4 |
| Humanities | 4 | 1 | 2 | 2 | 3 |
| Creative arts | 6 | 1 | 3 | 7 | 6 |
| Education | 4 | 1 | 2 | 2 | 3 |
| Other | 1 | 1 | 1 | 1 | 2 |
| *Unweighted N (=100%)* | *628* | *714* | *1318* | *513* | *2258* |

Half of students who had gained two or more Higher Grade awards in science subjects, or one or more subjects in technology were studying SET (48% and 52% respectively). 40% of students with Higher Grade mathematics were studying SET. This compares with around one third (32%) of all students in advanced courses who were studying SET.

Medicine and dentistry, and subjects allied to medicine, were two subjects areas studied by a substantial proportion of science-qualified young people. One quarter of students with two or more awards in science were studying medicine and dentistry or subjects allied to medicine, and among females with two or more science passes the proportion was 34% (table not shown).

A relatively low proportion of young people with two or more science Higher Grades took business and administration courses (7% compared with 16% of all higher education students) but this was a major area studied by students with Higher Grade awards in technology or mathematics (12% and 15% respectively).

Levels of participation in other subject areas by young people qualified in science, mathematics and technology did not differ substantially from those of other higher education students.

## SUBSEQUENT DESTINATIONS

We have seen that for the vast majority of students in spring 2001 the reasons for studying higher education courses included the aim to get a satisfying, well-paid job (see Table 4.4). It is too early to say whether their hopes will be realised. However, the employment prospects of graduates are likely to be a factor influencing their choice of course, especially in view of the problems of student debt (HM Treasury, 2002). Some indication of students' prospects of obtaining a job can be obtained from data on the first destinations of graduates in 1999-00 (Scottish Executive, 2001a); selected data are reproduced in Table 5.3.

**Table 5.3 First destinations of first-degree graduates in Scotland, 1999-00 by subject**

| | Full-time study | Permanent home employment | Temporary home employment | *N (=100%)* |
|---|---|---|---|---|
| **SET** | | | | |
| Biological science | 34 | 35 | 11 | *1,378* |
| Physical science | 40 | 36 | 6 | *983* |
| Mathematics and Informatics | 15 | 62 | 7 | *866* |
| Engineering technology | 17 | 61 | 5 | *1393* |
| **Other** | | | | |
| Medicine & dentistry | 10 | 6 | 84 | *852* |
| Subjects allied to medicine | 15 | 54 | 22 | *1,300* |
| Agriculture & related subjects | 8 | 54 | 12 | *326* |
| Architecture, building & planning | 25 | 53 | 9 | *657* |
| Social studies | 37 | 37 | 9 | *1841* |
| Business & administration | 12 | 62 | 10 | *2718* |
| Mass communication & documentation | 11 | 61 | 12 | *376* |
| Language & related disciplines | 26 | 35 | 11 | *1000* |
| Humanities | 31 | 38 | 11 | *826* |
| Creative arts | 27 | 44 | 10 | *750* |
| Education | 4 | 62 | 23 | *834* |
| Multi-discipline | 24 | 46 | 10 | *1851* |
| **All subjects** | 22 | 47 | 14 | *17,951* |

Note: other destinations were overseas employment:4%, believed unemployed: 5%, and other: 8%.
Source: (Scottish Executive, 2001a)

Less than half of Scottish first-degree graduates in 1999-2000 had obtained permanent UK employment, while 14% were in temporary employment and one fifth went on to further full-time study. Graduates with first degrees in mathematics and informatics, and engineering technology were relatively successful, and over 60% obtained permanent employment in the UK, as did graduates with first degrees in business and administration, mass communication, and education.

A very high proportion of graduates in medicine and dentistry entered temporary employment (84%), as did almost a quarter of graduates in subjects allied to medicine, and education. These patterns reflect vocational training and probation practices in related professions.

The proportion of first-degree graduates going on to further full-time study was exceptionally high in biological and physical sciences, social studies and humanities. This suggests that students in these subject areas are likely to face delayed entry to employment.

These data on first destinations of graduates provide only a limited picture of graduate recruitment. Nevertheless, the data suggest that employer's demand for graduates of mathematics and informatics, and engineering technology, was more evident in 1999-2000 than for biological and physical sciences. Therefore the balance of course choices by young people entering SET courses in higher education seems fairly sensible. One of the recommendations of the Science Strategy was that Future Skills Scotland should carry out an analysis of supply and demand for people with science qualifications, and this will give a fuller picture. At present there does not appear to be evidence of scarcity of SET graduates, but the Roberts Review has outlined potential difficulties, with more demand in some areas of SET than others.

The Science Strategy for Scotland includes a request for good quality, unbiased information and advice about careers opportunities in science. If there is genuine need to increase levels of participation in some areas of SET it will be important to demonstrate real employment prospects to attract potential students.

The curriculum covered by SET courses may also need up-dating to ensure that SET graduates have the full range of skills needed by industry. There may be a tension in the design of curriculum in higher education between the desire to prepare future post-graduate researchers to develop "blue-skies" research excellence, and the need to prepare undergraduates for non-university employment. The Roberts Review outlines mismatches between the skills of graduates and post-graduates and the skills required by employers, for example many have difficulty in applying their technical knowledge in a practical environment and are seen to lack strong transferable skills (HM Treasury, 2002). The Science Strategy for Scotland proposes that SET courses should develop generic skills of communication, decision-making and working in teams, and that students should have the opportunity to acquire business and entrepreneurship skills, and to undertake work experience (Scottish Executive, 2001b).

## SUMMARY

For the purposes of this study, SET courses in higher education include biological science, physical sciences, mathematical sciences and informatics, engineering and technology. On third of students taking **degree-level** courses studied SET:

- 11% studied mathematical sciences and informatics
- 9% studied engineering and technology
- 7% studied physical sciences
- 6% studied biological sciences.

One fifth of students taking **HNC/HND courses** studied SET:

- 10% studied mathematical sciences and informatics
- 8% studied engineering and technology
- less than 1% studied physical sciences
- 1% studied biological sciences.

Factors influencing the study of SET in higher education were:

- level of course;
- Higher Grade passes in specific subjects;
- numbers of science and technology subjects studied in S3/4, S5/6 and awards at Higher Grade;
- overall Higher Grade attainment;
- sex;
- family background.

Of the cohort as a whole, 11% were studying advanced courses in SET at age 18-19. There was a continuing influence of science subjects studied for Standard Grade at age 14-15; 24% of young people who studied two or more science subjects at Standard Grade went on to study SET in higher education compared with just 5% of those who studied one science at Standard Grade.

Among young people who had started a higher education course by 18-19 a substantial proportion were studying SET. Half of students who had gained two or more Higher Grade awards in science subjects were studying SET, as were half of young people who had gained one or more awards in technology, and two-fifths of students with Higher Grade mathematics.

Medicine and dentistry, and subjects allied to medicine, were two subjects areas studied by a substantial proportion of science-qualified young people. One quarter of students with two or more awards in science were studying medicine and dentistry or subjects allied to medicine, and among females with two or more science passes the proportion was one third.

Business and administration courses were studied by a substantial proportion of all higher education students, including students with Higher Grade awards in technology or mathematics.

Levels of participation in other subject areas by young people qualified in science, mathematics and technology did not differ substantially from those of other higher education students.

In 1999-00, 60% first-degree graduates in mathematics and informatics and engineering technology entered permanent employment compared with one third of graduates in biological and physical science. Over a third of graduates in biological and physical science went on to further full-time study.

## ISSUES ARISING FROM THE STUDY

In Scotland levels of participation in SET appear to be relatively high. However, there are continuing gender differences, with far fewer females studying SET than males. These gender differences in course choices reflect continuing differences in subject and career preferences by men and women in Scotland. They are also related to differences in participation in science and technology throughout the secondary-school stages.

Subject choices made at the end of S2, when pupils are aged 13-14 are important determinants of subsequent curricular options, and thus influence whether young people study SET in higher education. As we have mentioned in previous sections this makes it very important to ensure that pupils making their subject choices receive support in developing their career ideas, and good quality information about the value of science and technology qualifications to their future career opportunities.

There is some evidence from this analysis that students entering SET courses have lower levels of overall attainment in terms of Higher Grade awards than those entering other courses. This suggests that the expansion of higher education places in SET may have outstripped demand so that entry requirements for advanced courses in SET are less stringent than for other courses. We may speculate from this finding that the low levels of SET in sub-degree courses may indicate that lower-attaining students who would have done technician-level training in SET are currently able to enter degree courses.

The lower level of entry qualifications for SET courses provides some advantage in entry to higher education for male students in comparison with female students, because many more males than females enter SET courses.

Perceived career and job prospects are important influences on young people's choices of courses in higher education; almost all students anticipated that their courses and qualifications would lead to a satisfying, well-paid job. However, less than half of first-degree graduates in 1999-2000 entered "permanent" employment by the time of the Scottish Executive's first destination survey. It is not surprising, therefore, that the two areas of SET with the highest proportion of first-degree graduates achieving permanent employment - mathematics and informatics and engineering technology - were the areas attracting highest participation.

From the pool of young people with Higher Grade qualifications in science, maths and technology, who could potentially enter SET courses, a substantial proportion enter medicine, dentistry and subjects allied to medicine. These are applied areas of science which attract science-qualified young people, especially females. Business and administration is another area which attracts science-qualified young people, especially those with mathematics skills.

# CHAPTER 6: SUMMARY OF FINDINGS AND ISSUES ARISING FROM THE STUDY

This study has traced patterns of participation in SET from the end of compulsory schooling, through the S5 and S6 stages, and on to higher education.

## SUMMARY OF FINDINGS

### Compulsory schooling

- National curriculum guidelines ensure that all pupils study science throughout compulsory schooling. Less priority has been given to technology.
- The S3-S4 stages, when pupils study Standard Grade courses, are their first opportunity to choose which subjects to study, which to specialise in, and which to drop. Many pupils said that would have liked more advice than was currently available when making their subject choices.
- All pupils studied at least one science subject up to the end of S4, and one third studied two or more science subjects. Half of all pupils studied at least one technology subject:
- The strongest influence on young people's choices of science and technology subjects in S3-S4 were gender and attainment. Other factors were university aspirations, family background, local-area deprivation and type of school.

### Staying-on at school to S5 and S6

- Two-thirds of young people who completed compulsory schooling in 1998 stayed-on to post-compulsory schooling. Their principal reason for staying on was to gain qualifications that would lead to better careers.
- The majority of young people (89%) who had gained credit-level awards in science or technology at Standard Grade stayed on for S5, and over three-quarters stayed on for S6.

### Courses in S5/S6

- In S5 and S6 young people could choose the subjects they wished to study; half of S5/S6 students studied at least one science subject and one quarter studied two or more science subjects.
- The majority of students who studied two or more science subjects also studied mathematics.
- A quarter of all S5/S6 students studied at least one technology subject.
- The factors influencing the science and technology subjects studied in S5 or S6 are whether the young person had studied the subject in S4, and attainment in the subject; the number of science or technology subjects studied and attained in S4; mean award at Standard Grade (averaged over all subjects attempted); attainment in Mathematics at Standard Grade; sex; whether had university aspirations; school type.

### Courses, qualifications and other activities at age 18-19

- In spring 2001, when the SSLS cohort were surveyed for at age 18-19, just over half of young people were in the labour market, 44% of young people were in full-time education at college or university.
- A very high proportion of science/technology - qualified young people had entered full-time education by age 18-19 (89% of those with two or more Higher Grade awards in science).
- Almost one third of all young people at 18-19 were studying full-time degree-level courses, and 7% were taking other advanced courses.

- Factors influencing participation in higher education courses were: whether the young person stayed at school for S5/S6; number of Higher Grade awards at A-C; number of Higher Grade awards at A; number of science or technology subjects studied in S5/S6; number of awards at Higher Grade in science subjects; sex; mother's education; parents' occupation; home ownership; school type.
- The vast majority of students agreed that they were taking their courses so that they could get a satisfying job in future and because they were particularly interested in the subjects they were studying.

**Advanced courses in SET**

- On third of students taking **degree-level** courses studied SET. There were marked gender differences, with almost half of male degree-level students studying SET compared with one fifth of female degree-level students.
- One fifth of students taking **HNC/HND courses** studied SET, and this was strongly differentiated by gender: 39% of male compared with 6% of female HNC/HND students studied SET.
- Factors influencing the study of SET in higher education were: level of course; Higher Grade passes in specific subjects; numbers of science and technology subjects studied in S3/4, S5/6 and awards at Higher Grade; overall Higher Grade attainment; sex; family background.
- Among higher education students who had gained two or more Higher Grade awards in science subjects, half were studying advanced courses in SET and one quarter were studying medicine, dentistry or subjects allied to medicine.
- Of the cohort as a whole, 11% were studying advanced courses in SET at age 18-19. There was a continuing influence of science subjects studied for Standard Grade at age 14-15 ; 24% of young people who studied two or more science subjects at Standard Grade went on to study SET in higher education compared with just 5% of those who studied one science at Standard Grade.

## ISSUES ARISING FROM THE STUDY

### What are the purposes of science education?

A key objective of the Science Strategy for Scotland is to increase levels of participation in SET by young people at school and in post-school education. The Scottish economy needs young people with technological and scientific skills, and Scottish society needs citizens with confidence to engage critically and creatively with technological and scientific issues that arise. Thus, science education has two key purposes:

- To ensure that young people entering the Scottish workforce of the 21st century have the knowledge and skills necessary to promote economic, scientific and technological development;
- To give the future citizens of Scotland an understanding of scientific and technological approaches and evidence, so that they will be able to make informed decisions on scientific and technological issues.

Some comments on science education appear to emphasise a narrower, more elitist approach, which focuses on a select group of young people who can develop specialist skills in specific areas of science and technology, and who will put the UK at the cutting-edge of industry; for example the Roberts Review states:

> "*The challenge we face is to continue to attract the brightest and most creative minds to become scientists and engineers*". (HM Treasury, 2002)

It could be argued that the real challenge is to design curricula that provides scientific education for all young people, including those who go on to specialise in SET as well as those who will take this knowledge and understanding to other occupations and aspects of life.

## Why is participation in SET perceived to be a problem?

Levels of participation in SET in Scotland are relatively higher than elsewhere in the UK. Nevertheless, statistics from SHEFC indicate that levels of participation in some aspects of SET, particularly science and engineering, have not increased to the same extent as overall levels of entry to higher education. Specifically, participation in engineering has declined, while participation in computing has increased dramatically. Thus perception of declining participation in SET relates to relative decline in the strength of demand for courses in biological and physical science and engineering. Possible reasons for this decline suggested by other research include:

- negative images of science;
- relative difficulty of science subjects;
- low status of technology subjects;
- gender differences;
- the system of subject choice in schools;
- low levels of occupational awareness and careers guidance;
- problems of student finance.

This study has demonstrated that participation in SET at all stages of education from compulsory to higher education is influenced by a number of factors that have a cumulative effect:

- sex;
- attainment;
- social class;
- school type;
- university aspirations;
- prior attainment in SET.

Thus, policies to increase participation in SET need to address a number of barriers to participation faced by young people at different stages of their education.

## Policies to raise participation in SET

The Science Strategy for Scotland includes a number of actions to improve participation in science at school, including questions about the curriculum to be addressed by Learning and Teaching Scotland, provision of additional science teachers, and improved teacher education and CPD. At the post-school stages the strategy includes an analysis by Future Skills Scotland of the supply and demand for people with science qualifications, and provision by Careers Scotland of information and advice about career opportunities in science. Findings from this study suggest a number of questions that might be considered as part of the strategy.

## Questions about the curriculum

Learning and Teaching Scotland has been asked to prepare exemplar materials for teachers of science in primary and secondary school, and to advise how best to ensure that all school pupils have the opportunity to acquire the capacity to cope as citizens and decision makers with scientific issues.

Designing curricula for technology and science to meet this need is challenging. At present every young person in Scotland studies at least one science subject to the end of compulsory schooling, and thus it appears that we are some way towards ensuring that all young people have some understanding of science. However, in order to give future citizens a critical understanding science education needs to provide "knowledge about science" rather than scientific knowledge itself, and to develop the skills to engage critically with science, and to ask the right questions (Ryder, 2001). A recurrent theme of commentaries on science education - from the 1960s to the recent Robert's Review - is that science is taught as a body of facts together with a set of mechanical processes. Rarely is the status of knowledge questioned or even opened up for discussion (Driver *et al.,* 1996).

Existing national qualifications in chemistry, physics and biology focus on detailed scientific content which may make these subjects appear relatively difficult, abstracted from real-life experience, and thus uninteresting and unattractive to young people. Existing courses appear to focus on providing preparation for study of science at university. However, in 2001 just 11% of the whole SSLS cohort studied SET in higher education. We need to ask whether the needs of the other 89% of young people were provided for by the courses currently on offer in schools.

Science is often described as "difficult", and this may be part of the reason why half of young people in the post-compulsory stages decide not to study any science. The Roberts Review recommends that the examination boards should ensure that levels of difficulty are the same across subjects. However, the problem may not necessarily be of different standards between subjects but of the analytical skills required, and young people's confidence in employing these skills may influence their perceptions of relative difficulty. Those studying two or more sciences at Standard Grade were more likely to continue studying science, and it seems likely that they had developed more confidence in using scientific skills. The issue of perceived difficulty of science subjects may be linked to the increasing practice in schools of setting by ability, especially in mathematics; pupils allocated to middle and lower sets in mathematics do not have the opportunity to study aspects of mathematics that would help them in the study of physical sciences. Consequently, these young people are very likely to gain the impression that they are "not good enough to study mathematics and science".

A further part of the problem may be the existing division of subjects at Standard Grade into chemistry, physics and biology, with (general) science provided only to the low-attaining pupils. This requires young people to specialise at a very early stage; gender differences emerge in the choice of subjects, and social-class differences are reinforced by the allocation of low attaining, low social-class pupils to the (general) science option. It would be beneficial to consider ways of weakening the boundaries between science subjects and creating a more holistic approach. An interesting approach to science education being developed south of the border is to develop the understanding of "consumers" of science in addition to provision for potential "producers" of science. The modularised structure proposed for the GCSE science curriculum in England provides for single, double and triple awards in science so that all pupils would study "knowledge about science" for a single award, while double and triple award students would have opportunity to study all three science subjects to a level that would allow subsequent specialisation at A-level. This may be a model which merits consideration in Scotland also, but it is not clear whether this model of science courses increases levels of participation in science. The Roberts Review reports that participation in Scotland has previously been higher than elsewhere in the UK.

A further issue is that in schools technology and science are separated - they occupy different modes of the curriculum, and technology is given lower priority than science. Many of the technology subjects have inherited the relatively low-status of practical subjects such as metal work and woodwork which tended in the past to be studied by low attaining males. Technology courses at Standard Grade cover the full ability range, and provide pupils with understanding and skills which could complement those experienced in science courses. As with science education, so with technology education, the challenge will be to educate all young people to think critically and creatively about the 'made' environment, as well as to educate the technologists and engineers of the future. The ability to evaluate technology, its' impact and effects, should have greater priority within the curriculum.

**Subject choice and careers guidance**

The Science Strategy includes examination of issues of supply and demand for science-qualified young people, and careers advice at the post-school stages. While this is welcome, there is an urgent need for enhanced careers guidance at the primary and early secondary stages of schooling. This report has chronicled the cumulative effect of subject choices at school on participation in SET in higher education. The crucial choices are made at the age of 13-14 when youngsters make their choice of Standard Grade subjects. If they choose to study two or more science subjects at Standard Grade there is a greater likelihood that they will study SET in higher education, but if they choose to study just one science at this stage it is very unlikely that they will study science at later stages. Young people making these important subject choices need to be more aware that studying science and technology can open up more career opportunities, and provide worthwhile skills. Qualifications in technology and science are useful in a wide range of careers. At this early stage, youngsters rarely have clear ideas about future careers and need more careers advice and support with decision-making at earlier stages of their education.

Research into the supply and demand for SET graduates will provide the basis for more informed decision-making by prospective entrants to higher education. The overwhelming majority of undergraduates were seeking a satisfying job to follow from the subject courses they were studying. However, at the end of their courses most faced the prospect of large student debts, and uncertain job prospects. Better information and careers advice may go some way to making their careers search easier. Perceptions of well-paid careers in computing and information technology have undoubtedly been part of the reason for the growth in entry to these areas of SET. However, the career prospects for graduates from other aspects of SET are much less clear. The problems graduates experience in securing careers in their chosen fields are difficult and demoralising for the individuals, and will provide negative feedback to future higher education applicants.

At present it is not clear whether Scotland really needs more SET graduates. The analysis of supply and demand carried out as part of the Science Strategy may clarify the position. If there is a need for more graduates in specific areas of SET, we need to ensure that SET courses provide the full range of relevant and transferable skills to enhance the employability of graduates.

**Widening access to higher education**

Participation in higher education is significantly higher in Scotland than in England, and recent policies have attempted to widen access to non-traditional students. However, these policies have created a more diverse intake of students in terms of levels of attainment and social-class background, with a substantial number taking courses at sub-degree level and particularly in subjects other than science and engineering.

Levels of attainment are the key factor determining entry to degree-level courses. In addition, this study confirms that there is continuing social inequality in entry with young people from high social class backgrounds, and those from independent schools, more likely to enter degree-courses than their peers with the same overall attainment who did not have these advantages. Social inequality is very persistent.

Financial constraints are an important issue for widening participation in higher education. Current student funding arrangements mean that students face a severe debt burden, and this provides a major obstacle for non-traditional students (Forsyth & Furlong, 2000). Problems of student finance are a further problem for participation in SET. Many students need to take part-time jobs to ease the financial burden of study in higher education, but this is more difficult for students in science and engineering courses which have longer contact hours than other courses.

There are very marked gender differences in participation in SET, despite a number of initiatives to try to encourage females to enter SET courses in higher education. It appears that science-qualified females are more likely to enter the courses related to medicine than to enter SET.

Higher Grade qualifications in science provided young people with an advantage with respect to entry to degree-level courses, and they were more likely to enter degree-level courses than their peers with the same overall attainment who did not have science qualifications.

In particular, students were able to enter degree-level SET courses with lower levels of overall Higher Grade attainment than students entering other courses. It appears that the downturn in number of SET applicants may have led science and technology faculties to accept applicants with more marginal qualifications than in other subject areas.

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# APPENDIX 1: DATA USED IN THE STUDY

The main source of data for the study is the Scottish School Leavers' Survey (SSLS), linked to data on courses and examinations provided by the Scottish Qualifications Authority (SQA). The SSLS is a postal-questionnaire survey of a nationally-representative sample of young people who attended secondary school in Scotland. The study focuses on SSLS Cohort 2, which was first surveyed in spring 1999, and followed up in spring 2001. Cohort 2 comprises a 20% sample of all young people who completed S4 in 1998. The survey was conducted by the National Centre for Social Research on behalf of the Scottish Executive (Lynn *et al.*, 2001).

The survey data have been linked to records provided by the SQA of the young people's examinations at the end of S4, S5 and S6 including subject, national qualification level and award. The number of cases in the cohort sample for this study is limited to those for whom SQA records could be linked, and who responded to the survey:

- 7441 cases at sweep 1;
- 4919 cases at sweep 2.

The SSLS is a general purpose survey and includes information about young people up to the age of about 18-19 with respect to:

- courses studied in further and higher education, including the subject area, qualification and institution;
- pupil background characteristics including gender, age, socio-economic status and perceptions of school experiences;
- school characteristics including sector, denomination and local area;
- destinations and transitions in the 2.5 years after the end of S4.

There is thus a series of information that can be used to analyse progression within science and technology from the end of compulsory schooling (S4) through post-compulsory stages (S5 and S6) to tertiary institutions including further and higher education courses. There is information also about the destinations and transitions of young people who do not enter tertiary education. However, the SSLS does not include any specific questions relating to attitudes to science or reasons for studying or not studying SET.

Analysis of the data includes both descriptive statistics and statistical modelling of the factors associated with participation and attainment in science.

## WEIGHTING

The survey used birthdate sampling to construct a representative sample of the S4 cohort. However, it is likely that non-response introduced bias into the achieved sample, since some groups, such as the poorly qualified were less likely than others to respond to the questionnaire. Non-response bias at each sweep was therefore corrected using weighting factors based on sex and qualifications.

## A NOTE ON TABLES AND FIGURES

Percentages shown in the report have been rounded to the nearest whole figure; this means that some columns or rows may not sum to 100%. All percentages cited in this report are based on weighted data, while all bases are reported un-weighted. Un-weighted bases show the actual sample size on which the percentage estimate is based and thus give a more realistic idea of the reliability of each estimate.

# APPENDIX 2: STATISTICAL MODELS

The following tables present the results of multilevel statistical models described in the main report. The analyses were carried out using the MLWin software.

**Table 1: Factors influencing science subjects studied in S4: estimates (log-odds and standard errors) from multilevel statistical models**

| | Chemistry | Physics | Biology | General science |
|---|---|---|---|---|
| Sex | | | | |
| • *Female (reference category)* | | | | |
| • Male | +0.41 (0.06) | +2.24 (0.12) | -1.43 (0.06) | ns |
| Standard Grade Attainment | | | | |
| • Very low | -1.70 (0.12) | -2.02 (0.14) | -1.77 (0.10) | +2.44 (0.10) |
| • Low | -1.03 (0.13) | -0.99 (0.10) | -0.58 (0.07) | +1.43 (0.10) |
| • *Medium (ref cat)* | | | | |
| • High | +0.59 (0.07) | +0.70 (0.08) | ns | -1.84 (0.20) |
| • Very high | +1.29 (0.08) | +1.26 (0.09) | -0.22 (0.07) | -4.25 (0.72) |
| Interaction | | | | |
| • Male * low attainment | +0.38 (0.16) | ns | ns | ns |
| University aspirations | | | | |
| • *Does not want to go to university (ref cat)* | | | | |
| • Wants to go to university | +0.41 (0.06) | +0.68 (0.11) | ns | -0.48 (0.08) |
| Interaction | | | | |
| • Male * wants to go to university | ns | -0.45 (0.14) | ns | ns |
| Parents' education | | | | |
| • *Parents left school at minimum age (ref cat)* | | | | |
| • Father had post-compulsory schooling | +0.16 (0.07) | ns | +0.10 (0.06) | -0.28 (0.12) |
| • Mother had post-compulsory schooling | +0.20 (0.07) | ns | ns | ns |
| Father's occupation | | | | |
| • Professional/intermediate | ns | +0.20 (0.06) | ns | -0.27 (0.11) |
| • Skilled non-manual | ns | ns | ns | ns |
| • *Skilled manual (ref cat)* | | | | |
| • Semi-skilled/Unskilled | -0.20 (0.09) | ns | ns | ns |
| • not known/unclassified | ns | ns | ns | ns |
| Mother's occupation | | | | |
| • Professional/intermediate | +0.17 (0.07) | +0.14 (0.07) | +0.13 (0.06) | -0.64 (0.12) |
| • Skilled non-manual | ns | ns | ns | -0.39 (0.10) |
| • *Skilled manual (ref cat)* | | | | |
| • Semi-skilled/Unskilled | ns | ns | ns | ns |
| • not known/unclassified | ns | ns | ns | ns |
| Local area deprivation | | | | |
| • *average deprivation (ref cat)* | | | | |
| • deprivation one standard deviation above national mean (z-score) | +0.06 (0.03) | ns | -0.07 (0.03) | ns |
| • unable to link | ns | ns | -0.22 | ns |
| School type | | | | |
| • *state funded (ref cat)* | | | | |
| • independent | ns | +0.83 (0.18) | +0.38 (0.18) | - |
| Interaction: male * independent school | ns | -0.85 (0.24) | +0.53 (0.23) | - |
| Mean for reference category | -0.93 (0.08) | -2.31 (0.11) | +0.49 (0.05) | -1.45 (0.10) |
| Variance between schools | 0.19 (0.03) | 0.14 (0.03) | 0.15 (0.03) | 0.54 (0.08) |
| N of cases | 7441 | 7441 | 7441 | 7441 |

Notes: Each factor in the model is compared with a reference category.
ns denotes that the factor did not have a statistically-significant effect.
- denotes that the it was not possible to estimate the effect because there were too few cases.

**Table 2: Factors influencing the number of science subjects studied in S4: estimates (and standard errors) from multilevel statistical model**

| | Number of science subjects |
|---|---|
| Sex | |
| • *Female (reference category)* | |
| • Male | +0.15 (0.01) |
| | |
| Standard Grade Attainment | |
| • Very low | -0.23 (0.03) |
| • Low | -0.15 (0.02) |
| • *Medium (ref cat)* | |
| • High | +0.20 (0.02) |
| • Very high | +0.42 (0.02) |
| | |
| Interaction: | |
| • Male with very low attainment | -0.15 (0.03) |
| • Male with low attainment | -0.06 (0.03) |
| | |
| University aspirations | |
| • *Does not want to go to university (ref cat)* | |
| • Wants to go to university | +0.10 (0.01) |
| | |
| Parents' education | |
| • *Parents left school at minimum age (ref cat)* | |
| • Father had post-compulsory schooling | +0.05 (0.02) |
| • Mother had post-compulsory schooling | +0.05 (0.02) |
| | |
| Father's occupation | |
| • Professional/intermediate | +0.04 (0.01) |
| • Skilled non-manual | ns |
| • *Skilled manual (ref cat)* | |
| • Semi-skilled/Unskilled | ns |
| • not known/unclassified | ns |
| | |
| Mother's occupation | |
| • Professional/intermediate | +0.05 (0.01) |
| • Skilled non-manual | ns |
| • *Skilled manual (ref cat)* | |
| • Semi-skilled/Unskilled | ns |
| • not known/unclassified | ns |
| | |
| School type | |
| • *state funded (ref cat)* | |
| • independent | +0.26 (0.05) |
| | |
| Interaction: male in independent school | -0.17 (0.05) |
| | |
| Mean for reference category | 1.15 (0.02) |
| Variance between schools | 0.02 (0.002) |
| Variance between pupils | 0.23 (0.004) |
| | |
| N of cases | 7441 |

Notes:
ns denotes that the term did not have a statistically-significant effect.

**Table 3: Factors influencing technology subjects studied in S4: estimates (log-odds and standard errors) from multilevel statistical models**

| | **Technological studies** | **Craft & design** | **Graphic communication** | **Computing** |
|---|---|---|---|---|
| Sex | | | | |
| • *Female (reference category)* | | | | |
| • Male | +2.76 (0.17) | +1.39 (0.09) | +1.52 (0.14) | +0.88 (0.05) |
| Standard Grade Attainment | | | | |
| • Very low | ns | 0.014 (0.16) | -1.00 (0.15) | -0.78 (0.09) |
| • Low | ns | 0.14 (0.15) | -0.27 (0.11) | -0.24 (0.08) |
| • *Medium (ref cat)* | | | | |
| • High | ns | -0.23 (0.10) | ns | ns |
| • Very high | ns | -0.66 (0.12) | -0.22 (0.10) | ns |
| Interaction | | | | |
| • Male with very low attainment | ns | +0.60 (0.19) | ns | ns |
| • Male with low attainment | | +0.37 (0.17) | ns | ns |
| University aspirations | | | | |
| • *Does not want to go to university (ref cat)* | | | | |
| • Wants to go to university | ns | -0.37 (0.08) | +0.24 (0.15) | +0.15 (0.06) |
| Interaction | | | | |
| • Male with wants to go to university | ns | ns | -0.38 (0.17) | ns |
| Parents' education | | | | |
| • *Parents left school at minimum age (ref cat)* | | | | |
| • Father had post-compulsory schooling | ns | -0.44 (0.09) | ns | ns |
| • Mother had post-compulsory schooling | ns | ns | ns | ns |
| School type | | | | |
| • *state funded (ref cat)* | | | | |
| • independent | -0.99 (0.35) | -2.89 (0.53) | -1.00 (0.28) | -0.11 (0.22) |
| Interaction: male at independent school | ns | ns | ns | -0.67 (0.25) |
| Mean for reference category | -4.57 (0.16) | -1.89 (0.10) | -2.65 (0.13) | -1.13 (0.07) |
| Variance between schools | 0.57 (0.11) | 0.36 (0.06) | 0.51 (0.08) | 0.42 (0.05) |
| N of cases | 7441 | 7441 | 7441 | 7441 |

Notes: ns denotes that the term did not have a statistically-significant effect.

**Table 4: Factors influencing science subjects studied in S5/S6: log-odds (and standard errors) from multilevel logistic models**

| | Chemistry | Physics | Biology | Human Biology |
|---|---|---|---|---|
| Whether studied/ gained award in the subject in S4 | | | | see note 1 |
| • *did not study (ref cat)* | | | | |
| • studied in S4 | +0.92 (0.25) | ns | ns | ns |
| • gained award at general | ns | +1.72 (0.24) | +1.33 (0.19) | +0.89 (0.30) |
| • gained award at credit | +1.97 (0.20) | +3.38 (0.14) | +2.33 (0.10) | +1.32 (0.18) |
| Number of science subjects studied at Standard Grade in S4 | | | | |
| • *none (ref cat)* | | | | |
| • effect of each science subject studied | +1.02 (0.12) | ns | +0.51 (0.13) | ns |
| • effect of each credit-level award in science | ns | +0.33 (0.09) | +0.39 (0.11) | +0.35 (0.10) |
| Average award at Standard Grade in S4 (Grade point average) | | | | |
| • *Mean grade (ref cat)* | | | | |
| • one point above mean | +0.36 (0.10) | +0.43 (0.11) | ns | ns |
| Mathematics Standard Grade | | | | |
| • *no award at general/ credit (ref cat)* | | | | |
| • gained award at general | -0.54 (0.14) | ns | ns | ns |
| • gained award at credit | ns | +0.53 (0.15) | ns | ns |
| Sex | | | | |
| • *Female (reference category)* | | | | |
| • Male | +0.43 (0.10) | +1.11 (0.12) | -0.36 (0.10) | -0.64 (0.17) |
| University aspirations | | | | |
| • *Does not want to go to university (ref cat)* | | | | |
| • Wants to go to university | +1.02 (0.18) | +0.52 (0.17) | +0.79 (0.10) | +0.80 (0.24) |
| Career intentions | | | | |
| • *Career ideas unclear (ref cat)* | | | | |
| • Has clear idea of career | ns | +0.26 (0.11) | ns | ns |
| School type | | | | |
| • *state funded (ref cat)* | | | | |
| • independent | -0.50 (0.19) | ns | ns | ns |
| Mean for reference category | -5.52 (0.27) | -4.95 (0.24) | -3.91 (0.19) | -4.31 (0.28) |
| Variance between schools | 0.12 (0.07) ns | 0.09 (0.07) ns | 0.38 (0.08) | 2.14 (0.29) |
| N of cases | | | | |

Notes: ns denotes that the term did not have a statistically-significant effect.
1 - model for human biology refers to study of biology in S4.

**Table 5: Factors influencing technology subjects studied in S5/S6: log-odds (and standard errors) from multilevel logistic models**

| | Technological studies | Craft & Design | Graphic communication | Computing |
|---|---|---|---|---|
| Whether studied/gained award in the subject in S4 | | | | |
| • *did not study (ref cat)* | | | | |
| • studied in S4 | ns | ns | ns | ns |
| • gained award at general | +1.79 (0.49) | +1.17 (0.24) | +2.17 (0.25) | +1.64 (0.21) |
| • gained award at credit | +3.73 (0.28) | +3.27 (0.19) | +3.79 (0.20) | +3.58 (0.16) |
| Number of technology subjects studied at Standard Grade in S4 | | | | |
| • *none (ref cat)* | | | | |
| • effect of each technology subject studied | +0.67 (0.21) | +0.39 (0.13) | +0.33 (0.14) | ns |
| • effect of each credit-level award in technology | ns | ns | ns | ns |
| Number of science awards at Standard Grade in S4 | | | | |
| • *none (ref cat)* | | | | |
| • effect of each credit-level award in science | +0.38 (0.17) | -0.34 (0.11) | ns | ns |
| Mathematics Standard Grade | | | | |
| • *no award at general/ credit (ref cat)* | | | | |
| • gained award at credit | ns | -0.42 (0.19) | ns | ns |
| Sex | | | | |
| • *Female (reference category)* | | | | |
| • Male | +1.62 (0.43) | +0.80 (0.17) | +0.94 (0.18) | +1.13 (0.13) |
| University aspirations | | | | |
| • *Does not want to go to university (ref cat)* | | | | |
| • Wants to go to university | ns | ns | ns | +0.55 (0.18) |
| School type | | | | |
| • *state funded (ref cat)* | ns | ns | ns | -1.03 (0.33) |
| • independent | | | | |
| Mean for reference category | -6.96 (0.50) | -3.60 (0.17) | -4.56 (0.18) | -4.69 (0.22) |
| Variance between schools | 0.27 (0.29) ns | 0.40 (0.16) | 0.46 (0.19) | 0.37 (0.12) |
| N of cases | | | | |

Notes: ns denotes that the term did not have a statistically-significant effect.

**Table 6: Factors influencing participation in advanced courses in spring 2001: log odds (and standard errors) from multilevel logistic models**

| | Degree | HNC/HND | All advanced courses |
|---|---|---|---|
| At school for S5/S6 | | | |
| • *left school at S4/winter S5 (ref cat)* | | | |
| • had post-compulsory schooling | +0.85 (0.24) | ns | +1.02 (0.14) |
| Total number of awards at Higher Grade | | | |
| • effect of each HG award | +0.76 (0.04) | ns | +0.48 (0.03) |
| Total number of A at Higher Grade | | | |
| • effect of each HG award at A | +0.15 (0.04) | -0.45 (0.09) | +0.14 (0.04) |
| Number of science subjects studied in S5/S6 | | | |
| • effect of each science subject studied | ns | +0.38 (0.10) | ns |
| Number of awards at Higher Grade in Science | | | |
| • effect of each Science HG award | +0.28 (0.07) | -0.93 (0.15) | +0.22 (0.07) |
| Number of technology subjects studied in S5/S6 | | | |
| • effect of each technology subject studied | ns | +0.34 (0.10) | ns |
| Number of awards at Higher Grade in Technology | | | |
| • effect of each Technology HG award | ns | ns | ns |
| Sex | | | |
| • *Female (reference category)* | | | |
| • Male | ns | -0.30 (0.12) | ns |
| Mother's education | | | |
| • *no post-compulsory schooling (ref cat)* | | | |
| • had post-compulsory schooling | +0.19 (0.09) | ns | ns |
| Mother's occupation | | | |
| • *Manual (ref cat)* | | | |
| • professional/intermediate | ns | +0.51 (0.13) | ns |
| • Skilled non-manual | ns | +0.34 (0.13) | ns |
| • unskilled | ns | ns | -0.40 (0.10) |
| Father's occupation | | | |
| • *Manual (ref cat)* | | | |
| • professional/intermediate | +0.81 (0.21) | ns | +0.32 (0.08) |
| (interaction) Total HG awards x father professional/intermediate | -0.12 (0.05) | ns | ns |
| Family home | | | |
| • *not owner-occupied (ref cat)* | | | |
| • own home | +0.27 (0.13) | ns | +0.21 (0.10) |
| School type | | | |
| • *state funded (ref cat)* | | | |
| • independent | +2.08 (0.39) | -1.19 (0.46) | ns |
| (interaction) Total HG awards x independent school | -0.36 (0.09) | ns | ns |
| Mean for reference category | -4.52 (0.25) | -2.30 (0.10) | -2.80 (0.15) |
| Variance between schools | 0.03 (0.05) ns | 0.045 (0.071) ns | 0.096 (0.045) |
| *N of cases* | *4919* | *4919* | *4919* |

**Table 7: Factors influencing participation in Science, Engineering and Technology (SET) courses among young people in Higher Education in spring 2001: log-odds (and standard errors) from multilevel logistic models**

| | Biological science | Physical science | Mathematics & informatics | Engineering science | All SET |
|---|---|---|---|---|---|
| **Course** | | | | | |
| Degree-level (ref. cat) | | | | | |
| HNC/HND | ns | -1.90 (0.62) | ns | ns | -1.35 (0.34) |
| **Higher Grade pass in** | | | | | |
| • Biology | +2.92 (0.47) | ns | -0.59 (0.23) | -0.83 (0.30) | ns |
| • Chemistry | +3.28 (0.62) | ns | ns | ns | ns |
| • Physics | ns | +0.65 (0.22) | ns | +2.70 (0.31) | +0.67 (0.15) |
| • Mathematics | ns | ns | +2.05 (0.42) | ns | +1.03 (0.18) |
| • Technological studies | ns | ns | ns | +1.42 (0.33) | +1.61 (0.34) |
| • Craft & design | ns | ns | ns | +1.00 (0.33) | +0.64 (0.25) |
| • Graphic communication | ns | ns | ns | +0.92 (0.28) | +0.75 (0.23) |
| • Computing | ns | ns | +2.05 (0.19) | -0.90 (0.28) | +1.26 (0.16) |
| • English | ns | ns | -0.43 (0.26) | ns | ns |
| **Science focus** | | | | | |
| Number of science subjects studied in S3/S4 | ns | ns | ns | +0.54 (0.20) | ns |
| Number of science subjects studied in S5/S6 | +1.41 (0.33) | +0.99 (0.18) | ns | ns | +0.69 (0.15) |
| Number of HG awards in science subjects | -1.81 (0.56) | ns | +0.36 (0.14) | ns | +0.74 (0.18) |
| Number of technology subjects studied in S3/S4 | ns | ns | +0.34 (0.13) | +0.59 (0.17) | |
| Number of technology subjects studied in S5/S6 | ns | ns | ns | ns | ns |
| Number of HG awards in technology subjects | ns | ns | ns | ns | ns |
| **Overall attainment** | | | | | |
| Total number of Higher Grade awards | -0.29 (0.09) | -0.19 (0.07) | -0.27 (0.08) | -0.40 (0.07) | -0.52 (0.05) |
| Number of Higher Grades at A | -0.26 (0.07) | ns | ns | ns | -0.11 (0.04) |
| **Sex** | | | | | |
| Female (ref cat) | | | | | |
| Male | ns | ns | +1.80 (0.34) | +1.62 (0.27) | +1.35 (0.24) |
| (Interaction: male taking HNC/HND) | | | | ns | +1.03 (0.40) |
| (Interaction: male with HG award in maths) | ns | ns | -1.52 (0.43) | ns | ns |
| (Interaction: Male with 2+ HG in science) | ns | ns | ns | ns | -0.49 (0.15) |
| **Family background** | | | | | |
| Not lone parent family (ref cat) | | | | | |
| Lone parent family | ns | ns | + | ns | +0.65 (0.19) |
| Variance between schools | 0.0 ns | 0.41 (0.22) ns | 0.0 ns | 21 (0.19) ns | 0.092 (0.078) ns |
| N of cases | 2258 | 2258 | 2258 | 2258 | 2258 |

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