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IMAGES OF ENGINEERING: AN INVESTIGATION OF GENDER AND ATTITUDES TOWARDS ENGINEERING

by

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ABSTRACT

IMAGES OF ENGINEERING: AN INVESTIGATION OF GENDER AND ATTITUDES TOWARDS ENGINEERING

ELIZABETH ANNE HODGKINSON

The research presented in this thesis used a mixed method approach to investigate the attitudes of sixth-form students in two British cities, towards engineering as a career, with the aim of finding out which factors encourage or discourage young people from becoming engineers, and whether these differ for males and females. The study can be set in the context of the declining popularity of engineering as a career choice for males and the continuing under-representation of females, for whom engineering is a non-traditional career choice. The principal research hypothesis was that negative images of engineering discourage girls and many boys from considering it as a career, with a particular focus on whether engineering and the school subjects closely related to it, are considered to be more appropriate for males than for females.

The study was informed by a social science realist framework, in which 'attitudes' were not accorded the status of fixed attributes of individuals, but were understood as indicators of the underlying social construction of meanings and ideologies.

It was found that the students in this study had made subject and career choices that conform to traditional gender patterns. The intention to pursue engineering as a career was highly dependent upon sex, with males being almost seven times as likely to consider it as a career than females. Although the students did not consciously subscribe to sex-stereotyped views of subjects and occupations, these were inadvertently reproduced through the students' constructions of meaning.

Initiatives to increase female participation in engineering have been based on overly voluntaristic conceptions of choice, whereby women are seen to straightforwardly reject the masculine image of engineering. However, this research suggests that understandings of both gender and engineering can be better understood as less intentionally constituted in 'discourses', which reinforce the association between engineering and specific forms of masculine identity, to exclude most women and many men.

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INTRODUCTION

This thesis originated from a broad sociological and feminist interest in occupational gender segregation and a desire to investigate further why it is that males and females tend to follow different subjects of study, both in secondary and tertiary education, and to enter different occupations. The research presented here focuses on one aspect of this problem: that few women become professional engineers. Women remain largely absent from the profession despite long-term efforts to attract them, in the form of programmes and initiatives that span three decades. Engineering is an occupation worthy of special attention, since, despite the fact that women are now entering many other previously male-dominated professions in equal or even greater numbers than men (Lightbody and Durndell, 1998), of all the professions, engineering contains the fewest females (Wacjman, 1991). This applies equally to engineering higher education, where, in 2002, female applicants to undergraduate degrees classified as 'engineering' were the lowest proportion of applicants to any degree subject group (UCAS, 2003).

This issue is of concern to feminists and others concerned with equal opportunities. Both groups worry about women's exclusion from important spheres of knowledge, decision-making and opportunities to play a role in determining our increasingly 'technological' society. Generally women tend to be concentrated in a narrow range of low paid occupations, typically in personal services work, office work, teaching, welfare and health-related employment (Whyte, 1986; Witz, 1993; EOC, 2002). For this reason, these groups are concerned, not only that women are absent from scientific and technological decision-making, but that they are also missing out on the personal fulfilment and financial rewards to be gained from these 'higher status' occupations.

In common with the other groups, the engineering profession is also interested in tackling the issue of female under-representation, albeit for different reasons. Currently, the profession is struggling to attract young people into undergraduate education and training and this can be seen as part of a wider debate about national skills shortages in scientific and technological education and employment (Mason, 1999). Historically, engineering has never attracted more than a few women and therefore recruits to the profession have been almost entirely drawn from one half of the population – males. In recent years, however, there has been a downward trend in the number of males enrolling on undergraduate engineering courses and a skills-shortage in many engineering disciplines has ensued. As a result of these shortages, the engineering sector, along with government policy-makers, is more interested than ever in finding ways of attracting girls and women into careers in engineering.

This thesis brings together the shared concerns of these broad groups, all of which are interested in finding ways of increasing women's participation in engineering. The research explores some of the reasons behind the continued under-representation of females in engineering, but also examines the declining popularity of engineering as a career choice for males. One of the questions the research asks is: to what extent are young women and men rejecting engineering for the same reasons?

A diverse range of literature informed the thesis, though much of this was drawn from the feminist social scientific tradition, which has developed a substantial body of knowledge relating to women's relationship to science and technology. The work was also informed by a body of theory and research that was not *explicitly* feminist, but nonetheless addressed gender issues in science and technology and was useful in illuminating factors that affect the participation of males in these areas as well as females. Much of this second body of literature comprised educational studies in the sociological and psychological traditions, with a small amount provided by business studies and market research literature. A third 'non-feminist' body of knowledge (by this is meant writings that do not address issues of gender) was drawn from socio-historical studies of engineering, technology and science. This latter literature provided some background on the historical development of engineering education and the profession in the UK and the cultural, social, political and economic factors that shaped its development.

Two areas of focus provided the backdrop to the study. The first of these was the subject option choice process and the continuing disparities between females and males in their take-up of science and technology subjects at school. At the post-compulsory level, girls continue to cluster into the humanities subjects and biology and boys into the physical sciences and technology (Blackmore, 2001). This is considered important, since girls' 'failure' to choose options in the physical sciences and technology reduces their career opportunities in these areas, including engineering. One aim of this work then, was to find out *why* it is that so few girls choose to study these subjects. There is a growing literature to support the proposition that young people of both sexes are becoming less inclined to study the physical sciences and mathematics (see for example, Mason, 1999; Picker and Berry, 2000; Engineering Council, 2002; Canovan, 2003). Part of the study therefore included exploring the widely held assumption that girls, and indeed many boys, do not become engineers because they have negative attitudes to science and technology as subjects of study at school and that this leads to their rejection of engineering as a career.

However, becoming science-qualified is a necessary, but not sufficient condition for choosing engineering as a career. It follows from this that choices in science are only part of the story. Hence a second focus of the study addressed the attractiveness of engineering as a career, examining the image of engineering and its effects on the attitudes and choices of young people of both sexes. By comparing the attitudes and choices of adolescent girls and boys towards science and technology subjects in school and their perceptions of engineering as a career, the research set out to explore the way that gender acts to structure young people's aspirations and choices towards engineering. This thesis is informed by social theory and it is important to note at this stage that throughout this work, 'attitudes' are understood, not as static attributes or traits of individuals, but as indicators of underlying social processes or mechanisms.

Chapter One situates the research problem within a wider theoretical context. It begins with some definitions of engineering and some clarification of the meaning and scope of 'engineering careers' within the context of this investigation. It then goes on to present data to illustrate female under-representation in engineering employment and higher education. The Chapter then outlines a typology of feminist perspectives and approaches to the 'problem' of women and engineering, which are drawn from a wider body of feminist theory on gender, technology and science. Historical perspectives on the problem are also discussed, most notably that in the relatively recent historical past, females were actively prevented from becoming engineers and scientists through direct exclusion in the form of discriminatory policies denying them access to educational and occupational opportunities. The Chapter shows how, following long campaigns by feminist and women's groups during the 19^{th} and early 20^{th} centuries, and the gradual introduction of equal opportunities legislation (most notably the Sex Discrimination Act in 1975), many of the formal barriers to women's participation scientific and technological spheres were, arguably, dismantled. Sex-discrimination, then, was no longer seen as the main reason for the virtual absence of women from engineering and other explanations were sought. Women were ostensibly free to choose engineering yet did not do so, why is this? In an attempt to answer this question, feminist researchers moved on to produce a substantial amount of work on the less overt forms of sexism and discrimination that are embedded within the 'masculine' institutions and cultures of science and technology. Hacker (1990), Wajcman (1991), Henwood (1991), Cockburn and Ormrod (1993) and Webster (1996) are just a few examples of this kind of work. Over the course of time, the problem of women and engineering has then tended to be conceptualised in one of two main ways: either as a problem with girls and women, or a problem with engineering (Glover and Fielding, 1999: 58). In early work, some feminist research focused on issues relating to the 'internal states' of girls and young women. However, this approach is now less fashionable than in the past and more contemporary feminist work has been concerned to link women's relationship with engineering to wider structural forces, particularly the gendered division of labour and the masculine culture of science. Regardless of this burgeoning feminist literature, however, it is fair to say that many 'mainstream' approaches continue to reflect a perspective that locates the problem of female under-representation in the choices and attitudes of girls and women themselves. This approach can be criticised for at least two reasons. First it has a tendency to blame girls and women for their 'misguided' decisions (Henwood, 1996; Wyer and Adam, 1999; Glover, 2000). Second, it is based on a form of rational choice theory which conceptualises the individual as rational and autonomous (Henwood, 1998; Francis, 2000; Hughes, 2001) and somehow divorced from the social context in which choices are made. This thesis shares these views and proceeds from the assumption that choices must be explained in ways which can account for both agency and structure.

Gender and subject choice

Young people's subject option choices and images of engineering then are the two areas of focus for this study. Certainly subject choice in adolescence is an important issue, not least because this is a key stage in young people's lives where inequality of access to engineering begins. Gaudart (1991: 10) has argued that women's historical exclusion from education has determined the 'gender-specific disparities in participation in education, preferences for certain fields of studies, share of graduates and, consequently, in potential scientific and technical personnel'. Cross-national studies have shown that irrespective of discipline, proportion of females in the discipline, or country, women's participation in science, engineering and technology diminishes at every stage of the science 'pipeline' – from school through to employment in these fields (Hanson et al., 1996; Glover, 2000; Rees, 2001). One section of this pipeline that has been described as particularly 'leaky' (Hanson et al., 1996), is the stage at which young people make subject choices in the transition from compulsory education to post-compulsory education. In England and Wales, this transition takes place after GCSE examinations at the age of 16 years, when students going on to further education are able to choose for the first time which subjects they would like to specialise in at advanced level. Traditionally, the prerequisite A-level subjects required for most engineering courses have been mathematics and physics, with mathematics considered the more important of the two. Those students dropping these subjects after GCSE have considerably reduced, if not closed off, their opportunity to pursue engineering education. However, this 'filtering out' process disadvantages girls more than boys, as the former are more likely to choose to study A-levels in the arts, humanities and languages than in mathematics, the physical sciences or technology (Colley, 1998; Francis, 2000).

Explanations for the low participation of females in engineering-related subject disciplines have been wide-ranging. In the past, girls' rejection of the physical sciences was thought to be a result of innate differences in cognitive abilities between the sexes. In the 1960s and 1970s girls were consistently found to do less well than boys in science examinations and tests of visual-spatial and mathematical ability (Stoney and Reid, 1981; Birke, 1986; Whyte, 1986; Kelly, 1987a). At this period, the problem was couched in terms of girls' 'underachievement' in science and mathematics and many contributors drew on biological and genetic arguments to explain why females were not cut out to be engineers and scientists. The evidence for this argument was critically evaluated by many researchers, including Griffiths and Saraga (1979), Whyte (1986) and Kelly (1987a) and has been largely dismissed by feminists in favour of social explanations. Since that time, feminist research has done much to broaden the scope of explanations to include wider social structural and cultural factors to account for girls' rejection of science, as well as continuing to examine the 'individual' dimensions of the problem. Perhaps the strongest evidence against the theory of innate sexual differences in ability is that the gender-gap in scientific achievement that was evident twenty or thirty years ago has now disappeared. Girls now outperform boys at school in every subject at GCSE and in most at A-level, including those traditionally the province of boys (Francis, 2000; Quicke, 1998, DfES, 2002). So marked is girls' academic success, that ironically, there has been a shift of emphasis in many non-feminist accounts, towards interpreting the current gender gap in terms of boys 'underachievement' (Quicke, 1998: 229). In some cases there is evidence of a backlash, with boys depicted as 'victims' of girls' success (Blackmore, 2001: 128).

Negative images of engineering

In addition to examining some of the explanations for why girls tend to opt out of science and technology study at school, Chapter One also examines the role of popular images of engineering and how these might affect young people's aspirations towards it as a career. This part of the discussion shifts the focus from perceptions of subject disciplines to how young people's educational and occupational choices might be shaped by their perceptions, expectations and images of the work place and of particular careers. Lightbody and Durndell's work (1996a, 1996b and 1998), for example, has explored young people's aspirations towards careers in science and technology, drawing upon social identity theory to examine the extent to which their career choices are the outcome of a process of matching the image of a given occupation to their own self-concept. Within the engineering profession more specifically, there is a preoccupation with how popular perceptions of engineering as a career influence recruitment to the profession. The engineering community and the Engineering Council have long believed that negative images of engineering are one of the main barriers to the take-up of engineering careers, discouraging young people of both sexes from considering it. Several dimensions of this negative image can be identified, which may interact with young people's self-identities (including their gender identities) in a number of ways. Previous studies have found, for example, that engineering is widely perceived as boring, old-fashioned, asocial, low-status, low-paid, dirty, heavy work and a job that is inappropriate for females. These aspects of the image may have differential effects on different groups of young people and their orientations towards engineering and this work set out to find out if this was the case, particularly with respect to the way gender mediates these images. These two related themes, subject choice and images of engineering, were the main focus of this work, which explores the ways in which gender acts to structure choices in engineering within the context of co-educational secondary education. In order to shed further light on the issue of female under-representation, it was hoped that those barriers to engineering that may apply to both sexes could be identified and separated from those which may pose particular barriers to female participation.

Chapter Two situates the research in methodological context and describes the methods used to achieve the research aims and why these were chosen. The study uses a mixed-method approach, gathering data from sixth formers in co-educational secondary schools in two stages, using focus group interviews at the outset, followed by a postal self-completion questionnaire of a larger sample of students. A key part of the Chapter outlines the methodological approach to the work and why this was taken. In particular, the contribution of a realist framework is outlined, including the ways in which this model allowed a number of methodological and theoretical dualisms to be bridged, including the traditional 'divide' between quantitative and qualitative research. It also discusses the ways in which a realist approach was compatible with the feminist goals of the research.

The Chapter also shows how the research questions were refined and the hypotheses derived and operationalised, before going on to discuss procedural and technical issues relating to each of the two methods in more detail. Some issues of measurement and analysis are then discussed before concluding the Chapter by considering some of the ethical issues arising in connection with each of the two methods, and how these were addressed.

In Chapter Three the group interview findings are presented and discussed. Here, the ways in which gender might be 'working' to shape decisions towards engineering within the peer group context of late secondary school are explored by examining the students' constructions of their subject choices, career aspirations and images of engineering. One of the strengths of the focus group method was that it gave an insight into how the students themselves understood the issues relating to their choices and their beliefs about engineering and how they typically talked about them in their peer group. This meant that, while my agenda imposed some structure on the discussions, there was still scope for the students' agenda to be heard. The findings from these group interviews were useful in two main ways. First they helped to inform and develop the survey questionnaire used in the second stage of data collection and second, they could supplement the survey findings and help to make sense of them.

Chapters Four and Five present and discuss the questionnaire findings. Chapter Four focuses on issues relating to the students' subject choices, including their enjoyment and constructions of different areas of the curriculum, particularly with regard to whether subject disciplines themselves are perceived to be 'gendered' and what implications this might have for the students' aspirations towards engineering. Throughout the Chapter, comparisons are made between different groups of students' responses on the basis of their gender, intentions towards engineering and the particular subjects they were studying in the sixth form. The main purpose of this Chapter is to assess the nature of the relationship between students' perceptions of subjects related to engineering and their intentions towards engineering as a career.

Chapter Five extends the analysis further by presenting data relating to the students' career aspirations and their intentions and attitudes towards engineering. Data is presented on the careers the students aspire to, the things they value in a career, how much they feel they know about engineering careers and their images of engineering. Again, comparisons are made between different groups of students on the basis of gender, intentions towards engineering and subjects studied. One aim of this chapter is to find out what the students are looking for in their future careers and whether their constructions of engineering match these aspirations. It is worth noting that given the focus of the research problem, the central analytical variable for the study was gender. However this is not to imply that other variables, such as social class or ethnicity are not important. Nor does it imply that 'feminine' and 'masculine' are perceived as homogenous categories. Gender is indeed one of the main independent variables, but differences *within* the male and female categories are not ignored and within Chapters Four and Five, some elaboration analysis (see de Vaus, 2002) is used, to compare differences between sub-groups.

Chapter Six draws together the findings from the two studies and assesses them in the context of the existing theoretical literature, before drawing some conclusions from the research and their implications for future work in the area.

CHAPTER ONE:

Perspectives on women and engineering

Introduction

The central concern of this thesis is the under-representation of women in engineering occupations. Despite thirty years of equal opportunities legislation and numerous initiatives to encourage girls and women to consider engineering as a career, females remain a minority in the profession. Although women are now entering previously male-dominated professions such as law, medicine, dentistry and veterinary science in equal or greater numbers than men (Lightbody and Durndell, 1998: 41), their presence in engineering remains negligible. This has long been a matter of concern to feminists and others concerned with equal opportunities, not least because they believe women should be equal participants with men in technological knowledge, decision-making and practices that have an important impact on all our lives (Kelly, 1987a, Carter and Kirkup, 1990). However, women's absence from engineering is no longer only of concern to feminists. Whereas engineering has never been a traditional career choice for females, in recent years it has also become a less popular career choice for males, fuelling concerns amongst the UK engineering sector and the government about 'skills shortages that could damage the economy' (*engineeringfirst*, February 1998). The concern about the diminishing popularity of engineering can be seen as part of a wider national concern about skills shortages in science and technology more generally and the difficulties experienced by employers in recruiting graduates in engineering, the physical sciences and computing/IT disciplines (Mason, 1999). Now that there are fewer males going into engineering higher education and careers, the engineering sector is more interested than ever in finding ways to attract females to the profession.

This chapter will provide a review of perspectives that can illuminate the problem of female under-representation, whilst also taking into consideration that some of the barriers to female participation may similarly affect many males. It will bring together a range of viewpoints that feed into explanations of how and why gender shapes young people's relationships to science and technology as educational and occupational choices. The aims of the chapter are twofold. First, to contextualise the research problem within existing social-scientific theory and research in this area and second, to show how this body of knowledge has influenced the shape and direction of this thesis. Studies relating to women's opportunities in engineering have focused, not just on the barriers to women's *entry*, but also to their retention and advancement. This is because the problems for women taking up studying or working in engineering do not disappear once the choice to enter has been made (Bryant, 1984a; Glover, 2000). Whilst all three of these issues are important and interconnected, this research is primarily concerned with the first of these: the factors affecting females' (and to a lesser extent males') motivations and opportunities to enter engineering careers. It does this by examining young people's motivations towards engineering-related subjects at school and their images of engineering as a career. Before going on to examine perspectives on gender and engineering, the chapter will begin by providing some definitions of what is meant by engineering.

What is engineering?

Engineering is difficult to define, particularly in the UK, where it is such a broad and weakly defined hierarchy of occupations. Smith and Whalley (1995) make the point that in Britain, 'there is still no well-structured group of employees, defined either by qualifications or position in the division of labour, to which the title 'engineer' can be unambiguously applied' (1995: 2). The fact that engineering is difficult to define is significant for the research undertaken here, as, arguably, the confusion and uncertainty around understandings of engineering has contributed to its poor image and low popularity as a career choice. Certainly there is evidence to suggest that a large proportion of young people, especially females, know little about engineering (MORI, 2001).

According to Gregory (1971: 33) the term *engineer* 'is derived from the Latin *ingeniatorem*, meaning one who is ingenious or clever or cunning in devising'. Similarly, Glover and Kelly (1987) link the word engineering with *ingenuity*, and define engineering as 'the art of making things that are useful and work' (1987: 209) and Buchanan (1989: 11) defines engineering as 'an expression of the talent of *homo sapiens* for making artifacts'. Common to these definitions is a view of engineering as a practical and inventive occupation - indeed, many regard invention as the most significant and glamorous engineering activity (Glover and Kelly, 1987: 220). However, there is much more to engineering than this, the difficulty is the way in which engineering is defined is constantly changing. For example, Glover and Kelly make the point that many of the activities we classify as engineering today would not have been known as such before it became collectively organised as an occupation. Therefore engineers are those people who 'in an earlier era might have been called mechanics, artisans or practical people' (1987: 11). Smith and Whalley argue that definitions of engineering are problematic because in Britain, unlike most other societies, 'the term engineer denotes equally both a manual and a professional, white-collar occupation' (1995: 2). This may be due to the fact that British engineering has a long history of association with craft-work and has not been totally successful in establishing itself as a profession (Smith and Whalley, 1995). Glover and Kelly (1987) point out that Britain has a long history of valuing the non-technical and intellectual aspects of education above the technical and practical. They found that there is a lack of knowledge amongst the British public as to what engineering is and what engineers do. They also found that there is a tendency to conflate 'professional' engineers with 'ordinary' engineers (for example, people who service and repair washing machines or photocopiers) and to hold engineering in low regard in comparison with other professions, such as medicine and law (Glover and Kelly, 1987: 25).

Further confusion arises when assessing the position of engineering in relation to both technology and science. Engineering is commonly understood as 'technology', indeed, engineers have become synonymous with technologists. But engineering is also in relationship with science to the extent that much engineering depends upon an established body of scientific knowledge and those entering at the professional level are required to be scientifically trained (although this has not always been the case). Further ambivalence arises because the boundaries between science and technology are themselves complex and contested. Many commentators have criticised the widespread conflation of technology and science, with the subsequent conflation of the categories of 'engineer' and 'scientist' (Glover and Kelly, 1989: 3). Furthermore, they have argued that this model of the science-technology relationship has been hierarchical, treating technology as 'applied science' (Wajcman, 1991: 14). The view that science discovers and technology applies has been challenged by those who argue that technology is older than science and, in many places, exists without scientific input (Smith Keller, 1992: 21; Wolpert, 1992: 25). These commentators claim that, far from depending on science, 'technologists possess their own distinct cultural resources, which provide the principal basis for their innovative activity' (Barnes and Edge, cited in Wajcman, 1991: 14). Mayr makes the point that throughout history, many different models of the science-technology relationship have been postulated, most of which have seen science and technology as two distinct entities that are opposite and mutually exclusive, while others are more 'conciliatory', allowing for some overlap and common territory between the two (1982: 157). However, Mayr sees these debates as futile, claiming that 'if we can make out boundaries at all between what we call science and technology, they are usually arbitrary' (1982: 157). For him, science and technology are concepts that are subject to historical change and 'what these terms have meant to their users in various cultures and epochs has depended on the given realities of the moment' (Mayr, 1982:161).

While there may be no necessary consensus on the nature of the science-engineering-technology relationship, what we can say with certainty is that what we call 'engineering' encompasses a wide spectrum of occupations and activities. There are, for example, numerous branches of engineering, each relating to different materials and resources in the physical environment - civil, mechanical, electrical, electronic and chemical engineering to name a few. According to the Engineering Council's 2001 Survey of Professional Engineers and Technicians (that is, those registered with the Engineering Council), engineers are well represented in all sectors of the economy. The largest proportion (47%) are employed in the production industries, of which 38 per cent are in manufacturing, 8.5 per cent in construction and almost all the remainder are employed in the service sector (see table 1 below).

Table 1: Percentage distribution of Engineering Council registrants by main eleven industries 2001

Manufacturing	38.1
Finance and Business	20.7
Public Administration	10.2
Electricity, Gas & Water supply	8.7
Construction	8.5
Transport &Communication	6.3
Education & Health	5.7
Mining & quarrying	0.5
Wholesale & Retail Trade	0.5
Agriculture	0.2
Other Services	0.8

Source: Adapted from the Engineering Council's *Digest of Engineering Statistics*, 2002, p.46, (www.engc.org.uk/publications/statsdigest/Digest2002.pdf).
Categories derived from industry level Standard Industrial Classification (SIC) 1992

There is also a broad hierarchy of jobs and technical skills in the engineering industry, which can be divided into three main tiers. The graduate (or professional) level engineers are at the top of the hierarchy, working in managerial, design and development roles (Chartered and Incorporated Engineers). Next are the Engineering Technicians, who also carry a measure of supervisory and technical responsibility (Engineering Council, 2002). Lower in the hierarchy are the craftspeople, such as electricians, mechanics, fitters, turners and so on, then finally the least skilled workers, involved in assembly and machine operation at the production end of engineering (Swords-Isherwood, 1985, Cockburn, 1985a). This thesis is primarily concerned with professional engineering at the graduate entry level, and the barriers to females' (and to a lesser extent, males') entry to undergraduate engineering education and subsequent graduate employment.

Women's position in engineering

There is considerable variation in women's representation in different engineering disciplines in higher education. In 1999, for example, women were 24 per cent of applicants to chemical engineering, but only 8 per cent of applicants to electrical and electronic engineering (UCAS *Annual Report, 2000 entry*). There is also an important distinction to be made between the issue of women's access to these disciplines and how they fare once they are in, that is, between the issues of 'getting in' and 'getting on' (Glover and Fielding, 1999: 58). These are issues of horizontal and vertical gender segregation (Cockburn, 1985b; Witz, 1993), the former describing the over-representation of one sex (in this case males) in a particular occupation, and the latter describing how men are more likely to be found in the higher-grade jobs and women in the lower. Making this distinction is important and helpful in understanding women's relative position in various science, engineering and technology (SET) disciplines. Women are well represented *numerically* in some scientific disciplines, for example, biology, sociology and psychology. In every subject discipline, however, regardless of the degree of 'feminisation', the higher the level or grade, the fewer women are to be found (Glover, 2000; Blackwell, 2001). Engineering represents an extreme example of gender segregation, differing from most occupations in that females are a numerical minority at every level of the occupational hierarchy.

Women are vastly under-represented in the professional strata of engineering, which, of all the professions, contains the smallest proportion of females (Wajcman, 1991: 145). An examination of lists of registered engineers highlights women's minority position as professional engineers in the UK. The Engineering Council's *Digest of Engineering Statistics* 2002, reports that at the end of 2000, women were only 2.8 per cent of Chartered Engineers, 1.0 per cent of Incorporated Engineers and 1.1 per cent of Engineering Technicians.

In the UK engineering industry as a whole, women are concentrated in the lowest level, least skilled jobs, mainly in manufacturing (Devine, 1992; Webster, 1996). In her study of gender and technical know-how, *Machinery of Dominance* (1985b), Cockburn concluded that women's place in engineering is either in the support role of secretary to professional engineers, or, if they are involved in engineering work, they are the 'base-line, least skilled, lowest-paid assembly hands' (1985: 11). She argues that 'women are to be found in great numbers *operating* machinery .... but (women) continue to be rarities in those occupations that involve knowing about what goes on inside the machine' (1985: 11). There are few women then, in the higher echelons of engineering.

Women's minority position as professional engineers is unsurprising given that so few females become engineering graduates. Data on students in engineering higher education shows that in 2000, females were only 14.5 per cent of UK undergraduates accepted to engineering degree courses, and this proportion has remained largely unchanged since 1991 (Engineering Council, 2002). It is useful to examine different engineering disciplines separately, however, as some attract higher proportions of women than others. The UCAS annual datasets on UK applicants to courses for 2000 entry show that chemical engineering attracted the highest proportion of female applicants, at 29.7 per cent, and mechanical engineering the lowest, at 8.4 per cent. Apart from chemical engineering however, no discipline contains more than seventeen per cent of women.

Table 2: UK applicants to engineering degree courses, 2000 entry, by gender

	Total	% Women	% Men
Chemical	980	29.7	70.3
Production/Manufacturing	1,117	16.8	83.2
Civil	2,905	15.1	84.9
Electrical/Electronic	3,147	10.1	89.9
Aeronautical	2,071	10.2	89.8
Mechanical	4,929	8.4	91.6

Source: UCAS statistical enquiry service, http://www.ucas.ac.uk/figures/enq/index.html

Despite some variation in participation levels between different engineering disciplines, women remain a minority as students in *all* engineering disciplines. It is no surprise therefore, to find that there are few female members of staff in engineering higher education, particularly at the senior lecturer/researcher grade, where women constitute no more than four per cent of staff in any of the engineering disciplines (see Table 3). This applies even to chemical engineering where women are better represented numerically than in the other disciplines.

Table 3: Women as a percentage of full-time, wholly institutionally financed academic staff in selected engineering disciplines, by grade, UK, 1998/99

	Chemical	Civil	Electrical, Electronic and Computer	Mechanical, Aeronautical and Production
Professors	5.6	0.0	1.6	0.3
women (n=)	(4)	(0)	(5)	(1)
all (n=)	(71)	(154)	(297)	(267)
Senior Lecturers and Researchers	3.6	3.5	3.6	3.8
women (n=)	(4)	(9)	(20)	(20)
all (n=)	(110)	(256)	(544)	(526)
Lecturers	20.0	9.1	7.3	8.1
women (n=)	(26)	(52)	(74)	(80)
all (n=)	(130)	(569)	(1012)	(986)
Researchers	15.1	20.9	13.0	17.6
women (n=)	(5)	(18)	(30)	(52)
all (n=)	(33)	(86)	(230)	(295)

Source: Extracted from HESA, *Resources of Higher Education Institutions*, 1998/99

Why do we need more women in engineering?

There is currently a wide range of groups who would like to see more women entering engineering careers, including the engineering community, government ministers, industrialists, employers, the equal opportunities movement, science educators and feminists. All appear to be working towards a common goal – to increase female participation, although these groups may have different motives for doing so. This said, these motives are not necessarily mutually exclusive and often complement each other. Some groups are primarily interested in women as the answer to the skills shortages and view them as 'untapped talent' (Glover, 2000). For the UK government and the Engineering Council, the desire to attract and recruit more women to the engineering profession is underpinned by economic growth and investment arguments and (to a lesser extent), equal opportunities arguments. The concerns of these groups are largely prompted by the wider issue of national skills-shortages in scientific and technical employment. The current government's perspective on skills-shortages is exemplified in the Department for Trade and Industry's White Paper on "Science and Innovation", published in July 2000:

> There are important mismatches between supply and demand; particularly shortages of electronics engineers, computer scientists and of people with the technical skills to do the new jobs created by the knowledge economy (Chapter 3, paragraph 17, cited in *Digest of Engineering Statistics*, Engineering Council, 2002)

Within the engineering industry more specifically, some sectors are currently experiencing greater skills shortages than others. The Engineering and Marine Training Authority (EMTA) labour market survey, undertaken in 1999 found that at the graduate level of employment, some 35 per cent of enterprises in electronics manufacturing, and between 19-26 per cent of enterprises in mechanical engineering and 'three leading service sector industries' had found some difficulties in meeting their recruitment targets over the last three years (Engineering Council 2002).

For some time, engineering higher education in the UK has been perceived to be in 'crisis' due to a shortage of applicants to undergraduate courses. Higher education data shows that despite the expansion in higher education generally, applications to engineering degree courses have halved over the last ten years (Engineering Council, 2002). The higher education media frequently reports closures, cutbacks or rationalisation programmes in engineering education, which are blamed on the lack of applicants with the appropriate entry qualifications, usually mathematics and science, preferably physics, A-levels (Smithers, 2002; Elliot Major, 2002). Between 1998 and 2000, UCAS applications to the 'engineering and technology' subject group fell by more than two and a half thousand (Wild, 2001). In engineering higher education, a downward trend in home applicants to engineering courses has been evident for some years (see Appendix VII). With the overall expansion in higher education, engineering's market share has decreased and in 2001, applicants accepted to engineering were only 5.2 per cent of home students accepted to any degree course, compared with 10.7 per cent in 1990 (Engineering Council, 2002). The proportion of EU and 'other overseas' students accepted has remained relatively stable in many engineering degree disciplines in the five-year period to 2001, with the exception of mechanical engineering, which shows a steady decline in EU/'other overseas' entrants over this time period (see Appendix VIII). In a cross-national comparison of the proportion of graduates in each country holding engineering and natural sciences degrees in 1992, most other competitor countries surpassed the UK, which at that time stood at around 10%, whereas 40% of first degrees awarded in China and, within the EU, more than 20% of first degrees in Germany, Belgium, Finland and Denmark were in Engineering (Engineering Council, 1998).

Skills shortages are not new, however. As long ago as the 1950s, there was official concern about the shortage of scientists and technologists in the UK, when the problem was seen primarily in terms of a 'brain drain', with trained personnel leaving to seek better-paid jobs elsewhere (Glover, 2000: 18). It was not until rather later that women came to be seen as part of the solution. A discourse of women as an 'untapped resource' emerged in the Dainton Report (1968) and the Finniston Report (1980), both of which regarded women as 'a potential labour force at a time when an insufficient number of men were coming forward' (Glover, 2000: 19).

Feminists begin from a rather different position on why we need to see more women in engineering to that of many of the previously mentioned groups. Feminists are not so much interested in the skills-shortages in the engineering sector, as in gender justice, and the ways that women might suffer disadvantage in relation to their position in engineering, and science and technology more broadly. Feminists are likely therefore to view the 'problem' of women and engineering differently from governments interested in economic growth and the need for more engineers and scientists (Glover, 2000; Walker, 2001). Feminism is a school of thought underpinned by a political commitment to identify and overcome disadvantage suffered by women as a 'class'. It is by no means a unified body of thought (Jackson and Jones, 1998; Freedman, 2001), but most feminists would agree that women are disadvantaged relative to men in terms of their access to science, engineering and technology, both at school and work. Feminist perspectives on the problem of women and engineering can be drawn from a broader body of work on girls' and women's relationship to science and technology more generally, both in education and in employment. The earliest investigations were concerned with science, physics in particular, but later work came to include technological disciplines, such as computing and engineering. Some of these perspectives will be explored more fully later in this Chapter.

Different feminists have different motivations for wanting to increase female participation in scientific and technological fields, and, as shall be seen later, there are some feminists who do not believe it would be in women's interests to enter occupations such as engineering at all. Those feminists who *do* want to see women's participation in engineering increased argue that in various ways women have been, and continue to be, denied the opportunity to fully develop their talents and potential in scientific and technological occupations. Not only do women lose out in terms of their exclusion from influential forms of knowledge, but also in terms of the financial rewards to be gained from these jobs (Kelly, 1987a, Carter and Kirkup, 1990, Glover, 2000). Scientific and technological occupations are generally much more highly regarded and better paid than many of the 'caring' professions traditionally entered by women, such as social work, nursing and teaching, where women are over-represented in the lowest level and most poorly paid jobs (Witz, 1993). Other commentators highlight the fact that women are absent from engineering knowledge and applications that affect all our every day lives at the most fundamental level:

> Technologies feed, clothe, and provide shelter for us; they transport, entertain, and heal us; they provide the bases of wealth and of leisure; they also pollute and kill. For good or ill, they are woven inextricably into the fabric of our lives, from birth to death, at home, in school, in paid work (MacKenzie and Wajcman, 1999: 3)

Almost everything we do in our day-to-day lives involves interaction with the products of technology and engineering. Technology affects people's lives, it can 'increase or diminish their life chances, shape their interests or determine their power' (Street, 1992: 6). It is predominantly men who are currently determining our interactions with the technological. In the main, women are excluded from these influential forms of knowledge, but should be equally involved in determining technologies as decision-makers and creators, rather than just as the recipients or users of technological knowledge and products (Cockburn, 1985b; Karpf, 1987; Cockburn and Ormrod, 1993).

Not only do many feminists believe that women would have much to gain by entering occupations like engineering, some also believe that *engineering* would have much to gain from women's involvement. They argue that these occupations are impoverished due to the 'lost talent' of women and other minority groups and the fact that these disciplines are not representative of the insights of all sectors of society (Hanson, 1996; Betz, 1997). Some feminists, along with many 'mainstream' groups, believe that women's 'special qualities' – whether derived from 'nature' or 'nurture', can improve engineering (Carter and Kirkup, 1990; Schiebinger, 1999). This group believes that women's 'caring' qualities would allow them to create more ethical and/or 'civilised' scientific and technological disciplines (Byrne, 1993, Schiebinger, 1999, Glover, 2000). The argument is that engineering would somehow be enriched by the contribution of women and indeed other minority groups, whose talents are currently 'going to waste' (Byrne, 1993, Schiebinger, 1999, Glover, 2000). This argument is widely used by advocates of the 'business case' for attracting women to science, engineering and technology (SET) occupations, who stress women's potential, not only to solve employers' recruitment problems, but also to improve company efficiency and productivity by adding fresh perspectives and innovations to the work force (see *Opportunity 2000* initiative, 1996). There is also a widely held view shared by many feminists and, indeed, mainstream groups, that the presence of more women in engineering will somehow 'de-masculinise' it. This assumption is underpinned by 'critical mass' theory, which has long been popular with liberal feminists and others concerned with equal opportunities. The theory proposes that once a certain proportion of women has entered engineering, its masculine image will disappear (see Byrne, 1993; Glover, 2000). Some take the argument further than merely the level of *image*, suggesting that if more women enter, engineering institutions will change qualitatively in culture, content and method because the presence of a larger number of women allows gender relations to be reshaped (Schiebinger, 1999).

As already mentioned, the argument that the presence of women would 'enrich' male-dominated occupations like engineering has been widely used to persuade skills-starved employers to recruit more women in the 'business case' argument for equal opportunities. In one sense the 'business case' for women's participation might be understood as a pragmatic feminist strategy for furthering women's opportunities in SET employment. However, the argument that the presence of more women would change engineering rests on particular assumptions about the 'nature' and characteristics of women and men. Many feminists disagree with these assumptions, taking issue with the implicit essentialism underpinning the notion that all women have characteristics in common that differ from those of men. They also challenge the idea that simply increasing the numerical representation of women is enough to change engineering or its work culture, as it ignores the resilience of existing power relations between the sexes (Byrne, 1993; Glover, 2000; Shiebinger, 1999).

As mentioned earlier, not all feminists accept uncritically the idea that more women *should* enter engineering. Cockburn (1985a) for example, has made the point that there are often high personal costs for women entering 'masculine' occupations like engineering, of which women are well aware. Carter and Kirkup (1990: 34) have also made reference to these costs, particularly the 'considerable psychological demands' placed upon women trying to balance the demands of their personal and professional relationships, in a job with a long-hours culture. These demands are evident in the high percentage of women in scientific and technological fields who remain single and childless (Hicks, 1991; Blackwell, 2001). In view of this, these writers view women as rational agents who are 'refusing', rather than *failing* to enter technology (Cockburn, 1985a: 56). Some feminists go as far as to reject the goal of women's participation in science and technology occupations altogether. Eco-feminism for example, is a radical form of feminist thought which has been accused of 'technophobia', due to its negative view of technology as oppressive to women (Stabile, 1994 and 1997; Kemp and Squires, 1997;) and its 'anti-modern attitude that rejects the present in favour of a temporally distant (i.e. non-existent) and holistic natural world' (Stabile, 1994).

Carter and Kirkup (1990), agree that we should not un-problematically assume that encouraging girls and women to become engineers is the 'right' thing to do. They believe that it is necessary to be cautious about encouraging more women to become engineers when 'engineering is likely to remain an uncomfortable environment for women for some years to come' (1990: 154). However, they also believe that engineering is too important to leave to one half of the population and that we should continue to develop a more critical understanding of the gendering of this profession and how it is perpetuated (1990: 2), which is one of the aims of this thesis.

Engineering has never been a traditional career choice for women, and far fewer girls than boys choose the pre-requisite combination of A-levels to qualify them for entry to engineering degree courses, usually mathematics and physics. Whereas most degree courses in subject areas other than engineering have been able to recruit applicants of both sexes, albeit in varying proportions, in effect, engineering courses have been almost totally reliant on recruiting from only one half of the undergraduate pool – males. Feminists have long been interested in uncovering the barriers to women's participation in science and technology occupations, but now that males are less likely to choose engineering careers than previously, there is a stronger interest than ever from groups outside feminism in explaining why females continue to reject it. So what are the barriers to female participation in engineering? And are these same barriers now being experienced by males, or have males turned away from engineering for different reasons?

Explanations for the low participation of women in engineering

1) 'Mainstream' perspectives[1]

At a very general level, explanations for women's relationship to engineering have commonly been expressed in terms of the wider 'nature/nurture' debate. The former arguing that women's underachievement in, or 'rejection' of, science, engineering and technology is somehow innate, natural, and immutable, whilst the latter claims that it is socially learned behaviour and therefore alterable. This thesis focuses on social explanations rather than biological ones, however the latter have been very influential in the past and it could be argued that they continue to have real effects on beliefs, expectations, attitudes and choices today (Trankina, 1993). For this reason they are worth discussing here.

Sex differences in aptitude

Biological explanations of women's low participation in scientific and technological disciplines have proposed that girls do not become scientists and engineers because they do not have the aptitude for these occupations. These arguments held significant sway in the 1960s and 1970s when the gap between male and female academic achievement in the physical sciences and mathematics was significant. Biological explanations have typically claimed that female 'underachievement' in the sciences is due to inherited sex differences in intellectual functioning. There has been no shortage of 'evidence' to support the claim that there are innate differences in ability between the sexes. Past studies have found, for example, that females perform better in tests of verbal skills, whereas males perform better in tests of visual-spatial ability and mathematics (Griffiths and Saraga, 1979; Whyte, 1986; Quicke, 1998). These sex differences in ability have then been used to account for the lower achievement of girls in maths and science and the subsequent under-representation of women in occupations that require these skills.

[1] 'Mainstream' is used here to refer to perspectives that are not explicitly feminist.

As Griffiths and Saraga point out, 'The biological paradigm is both very influential and widely accepted as a framework for the explanation of human social behaviour' (Griffiths and Saraga, in Hartnett et al., 1979:28). Certainly, biological arguments have had considerable appeal and influence with both academic and lay audiences and they are often used in popular and journalistic writing to 'explain' why women and men tend to follow different educational paths and be found in different occupations. Such arguments have attained the status of common sense knowledge. A contemporary example of this kind of biological determinism can be found, rather ironically, in a key Engineering Journal (*IEE News*, 1998: 6). The article is written by an engineer whose beliefs are 'based on over 30 years in further education in the field of electronics and electrical engineering'. The author of the article is aware that girls are often discouraged from engineering, or 'guided' into traditionally feminine careers by well meaning teachers. Nonetheless, he prefers to explain the scarcity of female enrolments in engineering with reference to 'evidence that the majority of females are not good at those aspects of study that require good spatial ability such as 'engineering' skills'. Equally, for this writer, this explains why so few men enter caring professions like nursing. For him 'it is the different operations of the male and female brains that is responsible' for the low number of female engineers and male nurses. He finishes the article by claiming:

> Long live 'equal opportunity', but is it not now time to recognise that no amount of career guidance or law enactment will ever produce equal numbers of female and male engineers or equal numbers of male and female nurses? (*IEE News*, 3 September, 1998: 6).

Despite their widespread appeal, however, biological explanations for female underachievement in, or avoidance of, SET have also been the most contentious for feminists and social scientists. This is because such arguments imply that change would be difficult, undesirable, 'unnatural' or impossible, and are frequently used to justify the existing inequalities between the sexes (Whyte, 1986). Feminists, who are politically committed to improving women's situation, believe that social-environmental factors are more likely to determine girls' and women's beliefs, opinions and choices concerning science, technology and sex roles than are any inherited sex differences in intellectual functioning.

Biological arguments have therefore been heavily criticised on a number of grounds, and not just by feminists. Firstly, it has been shown that gendered patterns of cognitive ability are not universal, but vary according to specific culture and socialisation (Griffiths and Saraga, 1979; Birke, 1992). For example, Scaife (1998: 61) gives the example of the Third International Maths and Science Study (1996), which produced data on the science performance of 9 and 13 year olds in Europe, the Americas, Africa, the Middle East, the Far East and Australasia. The results showed that in three-quarters of the participating countries boys outscored girls. However, he points out that whilst *within the same country*, boys tend to perform more highly than girls, it is still the case that girls in some countries scored more highly than boys in other countries. Secondly, it has yet to be proven that those biological differences that do exist between males and females would be sufficient to make any significant difference to their achievements, given the influence of so many other intervening factors (see Birke, 1992: 99). Thirdly, it is increasingly difficult to take seriously the argument that females are 'cognitively deficient' in the sciences and mathematics, when they are now outperforming males in *all* subjects at GCSE level and in most subjects at advanced level (DfES, 2002).

Due to the paucity of evidence to support the biological paradigm, many academics conclude that cultural and social factors are far more influential in explaining the gender imbalances in participation in scientific and technological disciplines than any biological differences between the sexes. Nonetheless, these biological arguments are remarkably resilient. Griffiths and Saraga noted in 1979 that such biological determinism has taken different forms in different historical contexts (Griffiths and Saraga, 1979). It is evident today in the growing popularity of the new discipline of evolutionary psychology, a discipline that claims to bridge the gap between biology and social and cultural behaviour (see for example, Badcock, 2000), but can tend to essentialise and dichotomise male and female 'natures'. The belief that gender differences in cognitive skills are innate can also be seen to underpin current debates about boys' 'underachievement'. Here, innate male ability is assumed, and boys' poor performance is attributed to laziness, whereas girls' 'success' is attributed to hard work rather than ability (Weiner, Arnot & David, 1997; Quicke, 1998; Scaife, 1998). The point is that these beliefs about biological differences in ability are harmful to girls. Trankina (1993) has pointed out that such beliefs may have a real impact on girls' attitudes, making them less confident in their abilities in maths and science and therefore less likely to choose them. Scaife (1998: 67) draws attention to the way that girls' confidence may be further undermined by teachers, who may have higher expectations of boys and are more likely to see them as high achievers.

As mentioned earlier in the chapter, different interest groups have different perspectives on what might be the social barriers to participation in engineering. Although this thesis is predominantly concerned with the issue of female under-representation, it also begins from the assumption that gender is a relational concept and that much can be learned about girls' and women's' relationship to engineering by also examining the experiences of boys and men (Walkerdine, 1989; Thomas, 1990). For the engineering community and the government, who are interested in the reasons why young people of both sexes are not choosing engineering, two social explanations have been widely used. The first of these is that there is currently a 'crisis' in mathematics (see for example, *New Civil Engineer*, 14 November, 2002) and, to an extent, the physical sciences in schools, whereby fewer students are choosing to study these subjects at advanced level than in the past. The second argument is that engineering has a negative image amongst young people. These are both explained below.

The crisis in mathematics and the physical sciences

It is frequently claimed that the fall in the number of recruits to engineering education and careers is due to the fact that fewer young people are studying the A-level subjects traditionally required for access to professional engineering (normally mathematics and physics), once these are no longer compulsory in school (Mason, 1999; Canovan, 2003). Popular explanations for the falling popularity of the subjects are first, that students find them more difficult than other subjects, second, that the shortage of qualified science teachers has diminished the quality of science teaching, making them less enjoyable than some of the 'newer' subjects on offer at advanced level. Yet is it actually the case that fewer students are studying these subjects at GCE A-level, or is it instead that the students achieving these qualifications prefer to enter courses and occupations other than engineering? An examination of national education statistics shows that in actual fact, mathematics remains popular, coming overall second only to English as the most frequently studied subject in the total A-level entries for 2001 (DfES, 2002).[2] The actual number of students taking mathematics A-level has fallen slightly from 1997/98 to 2000/01, but, due to demographic factors, this has been accompanied by a decrease in the population of candidates taking *any* subject. The *proportion* of 17 year olds passing maths at A-level has fallen only very slightly in the period from 1997/98 to 1999/2000, where it has remained broadly stable at approximately 7 per cent of the 17 year old candidates (DfEE, 2001). Girls, however, are much less likely to take maths at A-level than boys, comprising only 37.6 per cent of those taking the subject in 2001 (DfES, 2002). Again this gender differentiation in mathematics participation has remained stable over the period from 1997/98 to 1999/2000, with approximately 5.7 per cent of females in the 17-year old age group entering and passing mathematics, compared with 8.5 per cent of males (DfEE, 2001). Physics, another subject foundational to engineering, has also remained relatively stable in popularity over the same period of time, with approximately 4 per cent of the 17-

[2] This excludes General Studies, which is studied by the majority of post-16 students in state education in England.

year old population passing it. However, the gender imbalance is even greater in physics participation than in maths, with females constituting only 21.6 per cent of those taking the A-level in 2001 (DfES, 2002). As already noted, this gender differentiation in subject uptake extends to other engineering-related subjects, including design technology and computer studies, where males greatly outnumber females. Clearly females are less likely to study engineering-related subjects than are males, but the argument that a crisis in mathematics can explain the shortage of applicants to engineering degrees is difficult to sustain, given the stability of patterns of participation over time.

The negative image of engineering

The second and longer-term explanation for the downward trend in applicants to engineering is that an 'image problem' with engineering is largely to blame. It is claimed that engineering has a negative image for young people, who see it, amongst other things, as old-fashioned, boring, low-status work, dirty, harmful to the environment, and masculine (Glover and Kelly, 1987; Foskett and Hemsley-Brown, 1997). As long ago as 1981, following the Finniston report, the Engineering Council was established by government, with the aim of promoting the profession to industry and society at large, primarily for economic reasons (Glover, 2000). More recently, the engineering community planned a 'ground breaking' five-year advertising-led marketing campaign, aimed at changing the national perception of engineering and promoting engineering careers to young people. The campaign was developed by a major UK advertising agency, J. Walter Thompson, but was postponed due to lack of funding, which in its turn, is blamed on the downturn in the UK engineering sector (*engineering first*, August 1999). The implicit assumption underpinning these attempts to address the image problem with engineering is that reluctant recruits have somehow got it 'wrong' and the problem lies in their faulty beliefs and attitudes. This assumption extends to attempts to specifically address the issue of female under-representation. Since the 1980s, the Engineering Council has worked closely with the Equal Opportunities Commission on the issue of attracting girls and women to the profession. Both groups share the belief that the main explanation for the low participation of females in engineering lies in the sex-stereotyping of occupations and girls' perception that engineering is a man's job. Typically, in this approach, the solution to the problem of female 'underachievement' in science and technology is seen to lie in changing girls' attitudes. This view is exemplified in the following extract from Opportunity 2000:

> If employers in science, engineering and technology (SET) hope to increase the number of high achieving young women keen to enter science, it is clear they will now have to work on the "supply" side of the employment equation and set about reshaping attitudes of girls and young women towards careers in SET (Opportunity 2000, 1996: 2).

Many writers have taken issue with this conceptualisation of the 'problem', not least feminists, as will be seen in the next section of the Chapter.

2) Feminist perspectives

The masculinity of engineering

Feminists, as well as the Engineering Council, have engaged with engineering's 'image problem', but they have focused on one aspect in particular: the 'masculinity' of engineering. Whilst feminism comprises many diverse schools of thought, the one thing these have in common is the assumption that the physical sciences, technology and engineering are 'masculine' at some level. Feminist perspectives on the 'problem of women and engineering' have been informed by a larger body of theories of women's relationship to technology, which in their turn were developed from earlier studies of the 'problem' of women and science (Wajcman, 1991). Most current feminist perspectives on engineering have been informed by an important body of earlier work, which uncovered the 'androcentricity' of science. What was meant by the argument that science was 'androcentric' was that scientific knowledge, and indeed all forms of knowledge, are male-defined, because women have historically been excluded as 'knowers' (Lloyd, 1996; Garry and Pearsall, 1996; Smith, 1987, Harding, 1987; Hekman, 1990).

Whilst most feminist theorists agree that technology and masculinity are *associated*, they differ as to the nature and origin of this association and consequently, on whether and how it might be changed. Two main ways of conceptualising the 'masculinity of technology' can be identified, one which treats masculinity as an *image*, and the other which sees masculinity as *intrinsic* to technologies (Kelly, 1987c). These views need not be mutually exclusive, but in practice they are often treated as such by many groups (Roger and Duffield, 2000). In the first of these perspectives, technology tends to be conceptualised as gender-neutral. Here, the masculinity of technology is an image, a false, or distorted view of technology, which can presumably be corrected. This view is characteristic of the liberal feminist tradition, which has been concerned to explore the reasons why technology is seen as masculine and suggest ways in which the image can be changed in order to encourage more women to take up careers in technology. Arguably, one of the reasons that occupations such as engineering have a masculine image is that it is predominantly men who do them. In terms of numbers, it is males who study, teach and go on to pursue professional careers as engineers, scientists and technologists (Birke, 1986; Kelly, 1987c). It can therefore be argued that engineering and masculinity are mutually constituted. However, it is not unproblematic to refer to masculinity as a unitary category, when there are in fact, many ways in which to be a man (Connell, 1987; Mac an Ghaill, 1994). It may therefore be more fruitful to explore the idea that engineering might be associated with *particular* types of masculinity. This idea forms an important strand of this work that will be returned to in later chapters.

Much of the early feminist research on girls and science within the liberal tradition took a 'psychologistic approach', examining individual factors, such as personality and ability, to explain girls' under-achievements in and 'avoidance' of science at school (Kelly, 1987b). Women's problematic relationship to technology and science was seen to be a consequence of their, mistaken, perception of these areas as masculine. Consequently, many of the ensuing strategies and initiatives set out to address what they termed the 'underachievement of girls' in science education, and to correct their misconceptions about science. One objective was to attract girls and women into courses and careers in science and engineering by raising their awareness of the opportunities they were missing (Newton, 1981; Cockburn, 1985; Harding, 1986; Chivers, 1988; Hynes, 1993). This approach is exemplified in the GIST (Girls into Science and Technology) and WISE (Women into Science and Engineering) campaigns in the 1980s. Henwood (1996: 199) describes the WISE campaign as 'focused on women's 'choices', which it understands as being constrained both by a lack of information about scientific and technological work and by a masculine image of science and technology'. However, Henwood (1999: 22) criticises this 'liberal discourse' on gender-technology relations, because it embodies 'a determinist model of technology and a 'deficit model' of women and girls'. It assumes that the individual is autonomous and self-determining, over-emphasising agency, ignoring socio-structural constraints and problematising neither technology nor gender. Many feminists have therefore felt uncomfortable with this approach and have wanted to go beyond attempts to change the attitudes of girls and women, which they feel are misguided, or even insulting to females, with their tendency to 'blame the victim' (Kelly, 1987b; Wyer and Adam, 1999).

Later scholarship, still broadly within a liberal feminist perspective, moved away from the focus on girls and women, to examine more structural explanations for women's under-representation in these areas. The 'socially constructed' aspects of science and technology were emphasized and researchers began looking beyond girls' and women's personalities, abilities and 'choices' to the social 'barriers' preventing their participation in these areas.

Such barriers have been identified at both the structural and the symbolic levels, and are seen to result from cultural beliefs and practices. Structural barriers include institutional and organizational practices and policies which explicitly exclude women, or restrain their access or involvement (Breakwell, 1986). Other, more symbolic barriers, function less overtly to discourage girls and women from, or cause them to reject occupations like engineering. One example is the way the dominant gender ideology shapes attitudes. This ideology dictates what is appropriate or 'natural' work for men and women, in turn reinforcing the stereotype of engineering as an activity appropriate for men. These cultural beliefs are said to be reproduced through socialisation practices in the family and school, and have the effect of discouraging girls from studying the subjects necessary for occupations like engineering and from pursuing careers in these professions, which are stereotyped as masculine (Evetts, 1996). In response to this perspective, the way science was taught in schools became a focus of criticism, with an emphasis on the 'androcentricity' of the curriculum. The masculine image of occupations like engineering was said to be reinforced by the ways in which science and technology are presented in the classroom and represented in educational curricula in ways which exclude girls' experience and world views (Whyte, 1986; Kelly, 1987c).

For liberal feminism, then, the 'problem' of women and technology has typically been seen as one of *access* and the solution is seen to lie in changing socialisation processes and equal opportunities policies (Wajcman, 1991). Liberal feminism has had an enormous influence on social policy initiatives and as Rosser has argued, its goals and objectives underpin the majority of the US National Science Foundation's programmes for women and science to this day (Rosser, 1998). However, this approach has been criticized for its tendency to 'blame' girls, or their parents (Glover, 2000), since their socialization is seen to be 'lacking' in some respect and in need of correction to help girls and women enter technological education and careers. For this reason, some have termed this solution to the problem the 'deficit model' (Wyer and Adam, 1999; Glover, 2000). Furthermore, feminists from other theoretical traditions accuse this approach of conservatism, since it requires women to adjust to the existing technological order, without proposing similar changes in either men or technological institutions. These feminists argue that it is not the *image* of technology that needs to be changed, but technology itself.

Whereas liberal feminism has tended to treat the technological sphere as gender-neutral, albeit conventionally dominated by men (Webster, 1996), other feminist perspectives argue that technology is *gendered*. Here, the widely accepted association between technology and masculinity changes from one of image, to the view that technology is *inherently* masculine. Again, this perspective has been informed by the earlier work on 'androcentricity' and the idea that men have defined scientific and technological knowledge and institutions. Unlike the liberal feminists however, these analysts challenge the idea that technology simply shapes gender relations without being shaped *by* them (Gill and Grint, 1995). In this view, far from being neutral, technology is 'shaped' by social interests, including those of gender. Since women have traditionally been absent from technology, technological knowledge, practices and artefacts are therefore seen to embody 'masculine values' (Wajcman, 1991; Gill and Grint, 1995; Webster, 1996).

A very different and much more radical view of the masculinity of technology is exemplified in eco-feminism. Eco-feminism is a form of feminist thought which sees technology as not only gendered, but essentially and inherently *patriarchal*. Eco-feminism, as defined by Cox (1992: 282), 'draws together environmental, feminist and women's spirituality movements; it describes the diverse range of women's efforts to save the Earth from ecological disaster and incorporates a new feminist view of women and nature'. Eco-feminism was inspired by the 'difference feminism' of the early 1980s, which revalued qualities that our society had devalued as "feminine", such as subjectivity, co-operation, feeling and empathy (Schiebinger, 1999). Eco-feminism asserts that women's capacity to give birth makes them closer to nature and inherently pacifist and nurturant. It has focused particularly on reproductive technology, military technology and the ecological effects of other modern technologies (Wajcman, 1991). At its most extreme, eco-feminism states that Western science and technology embody patriarchal values and are used by men to dominate and control both nature and women (Wajcman, 1991; Gill and Grint, 1995). Mies and Shiva (1997) articulate the central tenets of eco-feminism in the passage below:

> The new developments in biotechnology, genetic engineering and reproductive technology have made women acutely conscious of the gender bias of science and technology and that science's whole paradigm is characteristically patriarchal, anti-nature and colonial and aims to disposses women of their generative capacity as it does the productive capacities of nature (Mies and Shiva, 1997: 499).

The eco-feminist position has usefully highlighted the ways in which technology has been used 'to oppress those who do not possess it or cannot engage with it' (Stabile, 1997: 509). However, it has been subjected to a powerful critique by those wishing to develop more productive engagements between feminist politics and the technological (Kemp and Squires, 1997). Eco-feminism is accused of reinforcing the association between technology and masculinity, by accepting dualist categories of women and nature and men and technology (Webster, 1996: 23). This perspective also reduces women to their sexual and reproductive capacities and reinforces a stereotype of 'female nature', which has oppressed women for centuries. Heavily reliant on a notion of 'patriarchy' which essentialises men, eco-feminism cannot account for the differences between men, forms of masculinity and their relationships to technology. Rather, according to Wajcman, it has a tendency to treat technology as a set of neutral artefacts manipulated by men in their own interests (Wajcman, 1991: 25). Furthermore, eco-feminism conflates technology and patriarchy to such an extent that they become one and the same thing and the only strategy open to eco-feminists is to reject technology altogether (Gill and Grint, 1995; Stabile, 1997). According to Williams (2000) this form of 'rejectionism' is naive, because it assumes that it is both desirable and possible to return to a mythical 'pre-technological age'. It is also incoherent because it rejects some forms of technology, such as its military uses, whilst wanting to retain others, such as preventative vaccines or communications technology. Moreover, this response is politically disabling for feminism, since it leaves the technological power in men's hands. Much current feminist theory therefore distances itself from the 'technophobia', underpinning the eco-feminist view, reminding us that technology can be liberating as well as oppressive for women (Kemp and Squires, 1997).

A third feminist perspective on technology is known variously as 'socialist feminism', 'feminist constructivism', or 'technology as masculine culture' (Gill and Grint, 1995; Webster, 1996). These theorists share with eco-feminism the view that technology is gendered, but reject the essentialism, pessimism and separatism of this position, remaining committed to improving women's situation within existing science and technology. However, they also differ from the liberal feminist approach in arguing that assimilationist strategies are insufficient - existing technology and its institutions must change. Socialist feminism focuses on gender-technology relations in the context of industrial technology. Like liberal feminism it draws on historical insights, but particularly focuses on the interplay of patriarchy and capitalism to explain how men came to dominate and women came to be excluded from technological knowledge and skill during industrialisation (Webster, 1996). Some of these writers have shown that before the industrial revolution, women were active participants in technological invention and innovation, but became excluded from technology as a consequence of the gendered division of labour that followed the mechanisation of production. They document the process by which, once the production process moved away from the domestic setting to the new factories, working-class women, held back by their responsibility for children and relatives, were unable to compete in the workplace on equal terms with men. Paid work and home became separated, men came to monopolise the new skills and trades which developed and women were consigned either to the least skilled jobs, or to the domestic sphere (Arnold and Faulkner, 1985; Griffiths, 1985; Cockburn, 1985b; Wajcman, 1991; Webster, 1996).

These feminists have also pointed out that the very *definition* of technology has a male bias. This is because what counts as technology has tended to exclude women's activities and inventions (Linn, 1987; Wajcman, 1991; Gill and Grint, 1995). In response, feminist historians have reclaimed women's rightful place in technology by documenting the ways in which women who contributed to technological developments have been 'hidden from history' (Trescott, 1990; Wajcman, 1991; Hynes, 1993). For Wajcman, who is a key contributor to the 'technology as masculine culture' perspective:

> the enduring force of the identification between technology and manliness, therefore, is not inherent in biological sex difference. It is rather the result of the historical and cultural construction of gender' (Wajcman, 1991: 22).

For these theorists then, both technologies and gender structures are the outcomes of social arrangements, with their roots in past human practice (Webster, 1996: 4). Here, technology is treated as a culture with its own knowledge, values, beliefs, practices, styles of interaction and codes of language and dress. For Wajcman, this culture is one which 'expresses and consolidates relations amongst men', so much so that 'technical competence is an integral part of masculine gender identity', therefore it should be no surprise that women do not aspire to it (Wajcman, 1991: 22). This thesis builds on this idea by exploring the notion that technology consolidates and affirms membership of a *particular* form of masculine identity, which not only excludes women, but also those males who do not come to 'inhabit' this kind of masculinity (Mac an Ghaill, 1994).

The strengths of the 'technology as masculine culture' perspective are that, like liberal feminism, it is based on an anti-essentialist conception of gender that allows for the possibility of change through political intervention. However, this view goes further, in asserting that both technology *and* gender are socially constructed, it challenges liberal feminism's belief that women's under-representation in engineering is simply due to a lack of access to education, training or employment, or the effects of sex-role stereotyping. It also challenges the eco-feminist view of innate differences in values between the sexes. Moreover, by employing historical analysis, it is able to describe the specific ways in which technology became associated with men and masculinity (Webster, 1996). However, Gill and Grint (1995: 13) argue that whilst the 'technology as masculine culture' perspective is more sophisticated than both liberal and eco-feminist positions, there are still some limitations. They point out that this perspective employs inconsistent uses of concepts such as 'patriarchy' and 'ideology'. Terms like 'patriarchy', 'masculinity', and 'men' are used interchangeably, which allows theorists to 'explicitly disavow and yet implicitly draw upon essentialist accounts of the gender-technology relation' (Gill and Grint, 1995: 12). Similarly, they argue, theorists will sometimes use a notion of 'ideology' to which both men and women are believed to be subjected. This ideology attributes the gendering of technology to 'some bigger structure, such as 'masculinity' or 'patriarchy', which transcends individual men'. However, at other times this notion of ideology is not used and men are depicted as simply acting in their own (male) interests' (Gill and Grint, 1995: 13). As Wajcman herself admits, feminists have to tread the path between adopting an essentialist position that sees technology as inherently patriarchal, or losing sight of the oppressive structure of gender relations through an overemphasis on the variability of the categories of 'men', 'women' and 'technology' (Wajcman, 1991: 25). This is a path that must be negotiated in the work presented here, which in so doing, draws substantially upon the insights of a fourth feminist perspective, that of post-structuralist feminism.

Post-structuralist feminism emerged from the 'cultural turn' in feminist theory, which, according to Jackson (1998), can be traced back to the late 1970s, in the work of Juliet Mitchell. Mitchell drew on the work of Althusser, Lacan and Levi-Strauss to locate women's subordination in ideology, which was conceptualised as autonomous from capitalism, breaking with previously held theories, particularly those of Marxist feminism, which had tended to conceptualise women's oppression as determined by the needs of capitalism (Thomas, 1990). The newer form of theorising was attractive to feminists as it 'created a space to theorise women's subordination without having to relate it to the capitalist mode of production' (Jackson, 1998: 22). Feminists increasingly engaged with and developed post-structuralist ideas during the 1980s. Feminist reworkings of Foucault's concepts of 'discourse' and power have been found to be particularly fruitful for theorising the processes by which female oppression is reproduced and maintained (see for example, McNay, 1992; Ramazanoglu, 1993).

Post-structuralist feminism, in common with other forms of feminism, is underpinned by social constructionist ideas, whereby 'the search for the 'real' is replaced with a focus on the constitutive nature of language and discourse within a historical and cultural context' (Cammack and Phillips, 2002: 125). Both within and outside feminism, post-structural theory has been characterised by a rejection of some 'modernist' ideas in favour of alternative modes of theorising. An example of this is the 'anti-humanist' shift from studying the 'individual' to studying what is termed the 'subject'. The term 'subject' is preferred because it moves away from the philosophy of liberal individualism, which conceptualises people as 'autonomous beings, unconstrained by power structures and institutions, who can choose our 'lot' in life (Stacey, 1993: 65). Individualism is criticised for its lack of a theory of social structure and the tendency to view individuals as wholly in control of their destinies and therefore to blame for any disadvantages and failings they might experience (Henwood, 1996). In contrast, the term 'subjectivity' 'emphasises the ways in which our thoughts, feelings and activities are produced and limited by external constraints' (Stacey, 1993: 65). Importantly, this approach also allows for the subject to be active in this process, as Aveling (2002) comments:

> Such an approach posits a sense of agency and at the same time indicates that as historically and socially constructed subjects our choices are never wholly free (Aveling, 2002: 267).

In post-structuralist theory there is a particular focus on examining 'discourse', which, according to Weedon (1987) is 'a structuring principle of society, in social institutions, modes of thought and individual subjectivity' (Weedon, cited in Freeman, 2001, 90). A discourse, according to Burr (1995: 48) is 'a set of meanings, metaphors, representations, images, stories, statements and so on, that in some way together produce a particular version of events'. Discourses are the sites for interaction in which meanings are negotiated and contested. They are at the same time, the site of power relations, as different discourses represent different political interests and are in competition with each other (Weedon, 1987). In this sense, discourses such as those of gender, have the power to define 'appropriate' feminine and masculine behaviour, close off alternatives and in so doing, shape the subjectivity and identity of individuals. Unlike other forms of theory, however, the individual is not seen as entirely determined by this process, but as an active agent in the construction of meaning, which is never assumed to be fixed 'once and for all', but constantly 'in process' (Weedon, 1987: 99).

The rather fluid notion of discourse as the place in which meanings are both constructed and contested can be contrasted with the more fixed, psychologistic study of 'attitudes', which, for Burr (1995), are 'essentialist concepts of the 'personality' kind' (1995: 49). Of attitudes, Burr argues:

> These things are not a route of access to a person's private world, they are not valid descriptions of things called 'beliefs' or 'opinions', and they cannot be taken to be manifestations of some inner, essential condition such as temperament, personality or attitude (Burr, 1995: 50).

Henwood (1996, 1998), Francis (2000) and Hughes (2001) are amongst those who have applied post-structuralist concepts specifically to the understanding of women's position in science and engineering. Like Burr, Henwood (1998) has criticised accounts of women's choices which explain them in 'purely psychological terms, with no concept of gender as *social* and as related to differential status and power' (Henwood, 1998: 37, my emphasis added).

The research presented in the next few Chapters is concerned with exploring young people's attitudes, choices and images in relation to science, technology and engineering. However it views these through a post-structuralist lens, whereby these attitudes and images are seen, not as essential attributes of individuals, but rather as reflections of their shared constructions of meaning and indicators of underlying social mechanisms and processes. Aveling (2002: 267) has spoken of the way schools are an important site for the reproduction of gender relations, viewing them as 'discursive fields' within which young people make choices. Understanding sixth-formers' subject and career choices as the outcome of gender discourses which make available particular 'subject positions' in relation to the physical sciences, engineering and technology, enables these choices to be seen as 'neither determined, nor free, but both simultaneously' (Jones, 1997, cited in Hughes, 2002: 99). Importantly, understanding that 'individuals have different access to particular discursive positions' takes account of the power relations of gender and the structuring of advantage and disadvantage (Hughes, 2002: 100).

Notwithstanding some of the theoretical limitations and tensions arising from all of the feminist perspectives described above, feminist work has crucially shown how women's exclusion from scientific and technical occupations such as engineering is, in part, a product of particular historical circumstances. These have constructed engineering as a masculine activity at a number of levels, that is, in terms of its image, the nature of the work, the numerical and cultural domination of men in the discipline, and so on. More specifically, engineering has become synonymous with *particular* versions of masculinity, that is: heterosexual, white, technically competent, middle-class or working-class (depending upon occupational grade and type of work). Furthermore, these versions of masculine identity are those contained in Connell's concept of 'hegemonic masculinity' (Connell, 1987, cited in Mac and Ghaill, 1994: 12), which is the dominant masculine form in contemporary society, and is 'constructed in relation to and against femininity and subordinated forms of masculinity' (cited in Mac an Ghaill, 1994: 12).

These ideas will be returned to later in this work, before this, it is useful to consider the contribution of feminist historians, who have documented the ways that women have historically been excluded from science and technology within the sphere of education. This strand of work is of particular relevance to this thesis since it is concerned with the ways in which girls and women's access to educational opportunities have had and still do have, an important influence on their access to engineering careers. This is therefore the subject of the next part of the Chapter.

The historical exclusion of women from science and technology

Until the relatively recent past, women fared poorly in education compared with men. Britain has a long history of denying women access to educational opportunities and from entry to the professions (Deem, 1978, Lewis, 1992, Spender, 1997). It was 1920 before Oxford began to admit women to degrees and Cambridge not until 1948 (Deem, 1978). Furthermore, where women *did* enter professional occupations in the early part of this century, the existence of 'marriage bars' forced their resignation upon marriage (Lewis, 1992: 68). Awareness of this 'legacy' of discrimination aids understanding of the enormity of the battles women have fought to take their places alongside men in education and paid work.

Women's interest in science

Much of the current discourse on the 'problem' of women and engineering focuses on girls' 'lack of interest' and lack of skills in science and technology and assumes that a rejection of these subjects is universal amongst women and has always been so (Delamont, 1996: 96). However, feminist historians have been able to show that women have had a strong scientific identity, which dates back to at least the seventeenth century (Phillips 1990, Purvis, 1991, Delamont, 1996 and Spender, 1997). Phillips (1990), for example, has documented the ways in which upper middle-class 'ladies' were actively and enthusiastically engaging in science, which was considered an appropriate interest for women in those times. Usually under the instruction of men, who might be husbands willing to teach them, private tutors, or public speakers, these 'leisured' women were able to study such subjects as chemistry, mathematics, astronomy, botany and ornithology. One of the main forums for the dissemination of scientific knowledge for many of these women was the series of lectures which were given by the Royal Institution, founded at the end of the eighteenth century.

However, the affinity these middle-class women appeared to have with science can be construed more negatively when it is seen to be, in part, a response to their exclusion from the educational and professional opportunities open to men and an attempt to fulfil themselves intellectually in the only way open to them (Phillips, 1990). Women were believed to be of low intellect and excluded from studying the classics, which was considered 'unbecoming in the fair sex' (Phillips, 1990: 12), but essential for enhancing the social and intellectual status of 'gentlemen' (1990: 3). In contrast, science was perceived as lowly and associated with practical, menial work, therefore not worthy of academic study for men, but suitable for their 'ladies' to dabble in, especially since it was not that far removed from the 'science' of the kitchen! (1990: 3). Delamont has argued that since, in that historical period, science was unimportant for 'gentlemen', it was therefore 'not so firmly classified as masculine *and* therefore not constantly described as unappealing to women' (Delamont, 1996: 97). Neither was it always limited to upper class 'ladies'. Women of lower social standing were also finding opportunities to study science, primarily in the Mechanics Institutes which had been set up by the adult education movement to impart 'scientifically useful' knowledge to working men and to which women were admitted from 1830 onwards (Purvis, 1991: 37).

The ideal of womanhood

Later generations of younger, less affluent, schoolgirls in Victorian England were not so fortunate, they were more likely to study 'domestic science' than the physical and natural sciences. As education became increasingly a matter of public, rather than private responsibility and organisation, dominant social beliefs about women's 'nature', abilities and 'appropriate' roles in society exerted a profound influence on the learning experiences of girls and women. During the nineteenth century, the content of both middle and working class girls' education was increasingly shaped by the 'ideal of womanhood', which was underpinned by the idea of 'separate spheres' for men and women, with women assigned to the private sphere of the home and men in the public world of 'work'. The idea of separate spheres went hand in hand with the processes of industrialisation and technological development, where production increasingly shifted from the private to the money economy and work was moved from the home to the factory. Arnold and Burr (1985: 153) argue that the conjunction of religious interests with economic ones was important in reinforcing women's 'rightful' place in the home. The Evangelical movement, for example, was influential in bringing about the Factory Act of 1832, which 'protected' working-class women by restricting the numbers of hours they could work and allowed the public workplace to become dominated by men (Arnold and Burr, 1985: 153).

In the 'ideal of womanhood', the desirable model of femininity was that of 'virtuous woman reigning supreme in the home, endowing it with peace and security, running the household with skill and efficiency, and rarely venturing into the world beyond' (Burstyn, 1980). Although the 'ideal of womanhood' identified all women with domesticity, models of femininity differed depending on social class. For middle-class women this was that of the 'ladylike homemaker', whilst for working-class women the ideal was that of the 'good woman' (Purvis, 1991: 6). This ideology influenced the content of girls' education, which was seen to be primarily about training them for their future domestic roles and produced a curriculum divided along lines of both gender and class. Before the advent of mass state education, working-class girls and boys in the various charity, church, voluntary, factory and 'dame' schools would have shared a core curriculum of reading, writing, arithmetic and religious instruction. However, the girls had less time to spend on these subjects, as they were required to learn needlecraft and knitting as well. The emphasis on domestic subjects for working-class girls increased in the later part of the nineteenth century as the state began to exert more influence over the curriculum (Turnbull, 1987: 84). In 1878, for example, 'domestic economy' became a compulsory subject for girls in elementary schools and grants were made available over the following years to encourage the schools to teach further domestic subjects like cookery and 'laundry work' (Purvis, 1991: 26).

The impact of social class

Throughout the century, middle-class and working-class girls were educated separately and there was even more gender segregation in the curriculum of middle-class children, than in the working class. Like working class girls, middle class girls' education was also designed to fit them for their feminine role, but since the latter were not expected to support themselves in paid domestic labour prior to marriage, the emphasis was on social accomplishments which would help them to 'attract and impress a suitor' (Purvis, 1991: 64) and fit them for home life as a 'ladylike wife and mother' (ibid., p65). Unlike their brothers, who, once past infancy, were sent away to public boarding schools, middle-class girls were either taught at home by governesses, family members or friends, or they attended private day schools, income permitting. Whilst their brothers studied 'the classics', middle-class girls' education often emphasised social accomplishments at the expense of academic learning. Furthermore, since there were few opportunities for women in teaching to become academically qualified, educational content was uneven and often of poor quality. As regards higher education, this was simply not an option for women in the first half of the nineteenth century. Women were denied entry to universities and in any case, would have been inadequately prepared for it by their formal schooling (Purvis, 1991: 106).

Equality or difference?

Whilst women had been campaigning for centuries to improve educational opportunities for their sisters, the 1840s witnessed the beginning of an organised campaign by the 'women's educational reform movement' to improve and change the content of education for middle-class girls and gain entry to higher education. Although united in their aim to achieve more and 'better' education for girls and women, the campaigners were divided amongst themselves over what 'better' education meant and what the exact purpose of women's education should be (Spender, 1987: 7). Delamont has divided the educational reformers into two broad schools of thought on these issues: the 'separatists' and the 'uncompromising' (cited in Dyhouse, 1984: 55). In terms of the nature of education, the separatists felt that women had different needs to men and their education should reflect this, whereas the uncompromising campaigners believed that girls should have exactly the same education as boys. As regards the purpose of education, many went along with the idea that women's primary role was that of wife and mother and education would enhance that role. The more radical 'uncompromising' campaigners argued that becoming wives and mothers was neither possible nor desirable for all women and regarded education as a key to women's fulfilment and liberation and a means of preparing them to become self-supporting in paid occupations and professions. They met with fierce opposition from various social groups, including scientists, doctors and clergymen (Burstyn, 1980 145), whose various objections reflected the general view that educating women would mean 'ruin for women and the destruction of society' (Spender, 1987: 5). Reformers were forced to justify the case for women's education with a number of arguments. For example, persuading opponents that it was a good thing because it would enable single women, of which, at that time there was a considerable number, to become self-supporting, and citing evidence to reassure the opposition that higher education did not damage women's physical or moral health and that intellectual women still married and had families.

The low status of science and technology

In view of women's historical struggles to gain access to *any* formal education which went beyond training them for domesticity, it is hardly surprising that schoolgirls' formal exposure to any scientific and technical knowledge, other than domestic science and craft, was negligible. This lack of opportunity was compounded by the low British regard for science as a subject worthy of academic study. Unlike other European countries, British education was modelled upon a liberal, rather than vocational educational philosophy, having prided itself on a long tradition of educating its gentlemen, who, by definition did not have to work, in 'the classics', namely Latin and some Greek (Lawson and Silver, 1973: 198). By the mid 1800s, however, the curriculum of English public schools had been broadened to include the traditional humanities, mathematics and some non-compulsory 'modern' subjects, including French, drawing and science, although the classics were still the most prestigious subjects. This then, was the model of academic excellence upheld for the secondary education of middle-class boys.

Whilst there had been organised attempts to popularise science throughout the nineteenth century, most notably by two bodies, the Royal Institution, founded in 1799, and the British Association for the Advancement of Science, founded in 1831 (Phillips, 1990), Layton argues that the school curriculum was still 'largely untouched' by science by the middle of the nineteenth century (1973: 23), which continued to have a subordinate educational role compared with the classics. This argument is supported by Roderick and Stephens (1972) who claim that the advance of scientific and technical education was held back by three main factors. First, the State's disinclination to intervene in education, second, the longstanding tradition of 'liberal' education in English culture and third, the class attitude to education, which considered technical education to be appropriate for artisans, but not for the middle classes (1972: 10).

Unsurprisingly, it was pupils in the lower social classes who benefited most from what little scientific teaching there was at that time, which for younger children commonly took the form of the 'object lesson', invented by Pestalozzi and pioneered by Elizabeth and Charles Mayo in the early nineteenth century (Browne, 1991). As a method of teaching science, however, the object lesson had its limitations, not least because many of the teachers using it had little understanding of scientific principles and 'lessons degenerated into mechanical rote-learning of facts' (Browne, 1991: 11). However, whilst Layton (1973: 23) has argued that the available evidence of the teaching of science in elementary schools before state intervention 'suggests a picture of almost total neglect', it may well be that his view is the result of gender-blindness. For example, Phillips (1990: 238) has presented evidence to show that many working and lower-middle-class girls *were* studying science, which was a well-established part of the curricula in many girls' secondary schools in the 1860s. It would seem then, that science has held different statuses at different historical times and places and that this has had an impact on which groups have had access to it.

A concerted attempt to establish science as a core ingredient of a general education began around the mid-nineteenth century as part of wider curriculum activity in elementary schools (Layton, 1973: 16). Long-established debates over the 'relative merits of scientific and literary studies' continued, but the classics, connected with social status, gentility and humanization, reigned supreme as the model of education (Layton, 1973: 17). At the same time, however, there was an increasing belief that education 'had an important economic role to play by supplying the occupational skills needed in an industrial society' (Layton, 1973: 148). For this reason it is argued that the organised efforts to introduce scientific and technical subjects to the curriculum were spurred by the concern that Britain was losing industrial supremacy (Roderick and Stephens, 1972; Layton, 1973; Lawson and Silver, 1973; Glover and Kelly, 1987; Phillips, 1990). It would seem that today's concerns about the engineering crisis and the wider skills crisis in scientific and technological occupations continue to be motivated by the same agenda.

The women's education reform movement, containing members such as Emily Davies, the founder of Girton College, believed that reform could only succeed if girls and women 'insisted upon studying the same kinds of curricula and sitting the same examinations as men' (Dyhouse, 1984: 55). The problem was, the reformers' success in achieving the same education as men was to have a profound effect on women's future identification with science (Phillips, 1990). 'As women set out on the road to equality, they resigned the scientific identity that had been theirs since the seventeenth century' (1990: 235). The classics curriculum continued to be the most prestigious model of education. Following the Taunton Commission in the 1860s, the quota of classics in girls' schools was increased at the expense of science, particularly for the brightest women aiming for higher education, who were discouraged from taking science classes and advised to concentrate on the classics (1990: 254).

These then, are some of the ways in which it can be argued that gender power relations and ideologies in particular historical circumstances came to exclude women of all classes from science and technology. Historically, females have been actively *prevented* from participating in engineering, science and technology by discrimination, which denied them the rights to scientific education and employment. Most significantly, these events and processes defined science and technology as *masculine* domains. For the first three-quarters of the 20th century, girls and boys continued to receive a gender-divided education, particularly in the areas of craft and technology, with boys typically taking courses in woodwork and girls in domestic science. Following the Sex Discrimination Act (1975) however, it was unlawful to deny any boy or girl the opportunity to study whatever subjects they chose on the grounds of their sex. In practice, however, the 'hidden' curriculum continued to reinforce gender divisions. Despite the Act, schools did continue to restrict some subjects to boys only or girls only, or to pattern options in a way that limited choices (Deem, 1978), albeit unwittingly. Another example of the way gender-stereotyping was reinforced was in the way many schools would timetable a science subject against an arts subject (Skelton, 1993: 333). Furthermore, at the age of 14, pupils were able to specialise in subjects of their choice, which meant that in practice, girls opted out of the physical sciences, mathematics and technology in large numbers (Whyte, 1986).

This section of the Chapter has discussed the contribution of feminism to understanding women's exclusion from scientific and technological activity. Above all, feminism has emphasised the way that occupations such as engineering have been socially, culturally and historically constructed as masculine domains and that gender inequalities in access to education have been a key mechanism of this exclusion. The next and final sections of the Chapter will assess the evidence for gender inequalities in access to science and technology education today and examine some of the processes by which girls' exclusion from these areas is maintained.

Evidence of gender inequalities in education today

The impact of the National Curriculum

In the 1980s many of those concerned with equal opportunities in education were optimistic that the introduction of a compulsory core curriculum would help reduce gender imbalances in science and technology (see Ormerod, 1981). Not only would it offer all pupils equal access to the same curriculum, but it would also make science and technology compulsory subjects, preventing pupils from dropping them too soon and limiting their career options. In 1988 the National Curriculum was introduced in England and Wales. All pupils in state education, regardless of gender, study the same 'core' subjects at GCSE level, English, mathematics, science, technology, physical education and a modern language. The National Curriculum was viewed by many as a positive step towards gender-inclusive education, particularly as it made science and technology subjects compulsory until the age of 16, preventing pupils from dropping them too soon and limiting their career options. But to what extent has the National Curriculum reduced gender inequalities?

Certainly girls' current achievements in secondary school science and technology cannot be denied. Girls are now outperforming boys in most subjects at GCSE level, including the 'masculine' subjects such as mathematics, chemistry, biology, design & technology and computer studies. For example, in the academic year 1999/2000, 34 per cent of girls in England achieved grades A* - C in the 'core' subjects English, Mathematics, Science and a Modern language, compared with only 24 per cent of boys (DfEE, 2001). The fact that girls appear to have overcome their former underachievement in the sciences and now do so well relative to boys in all subjects, particularly in English, the humanities and foreign languages (Warrington and Younger, 2000), has led many to conclude that gender equality in education has been achieved. Some are so convinced of girls' success in fact, that perspectives on the 'gender-gap' in achievement have turned completely around, and a discourse of 'boys underachievement' has emerged which assumes that the problems with girls have been resolved and boys are now the group needing attention (Warrington and Younger, 2000).

Gender differentiation in subject choice

Despite equity legislation and the debate about boys underachievement, many writers have drawn attention to the ways in which girls continue to be disadvantaged, both in school and outside it (Weiner, 1997; Weiner, Arnot and David, 1997; Warrington and Younger, 2000; Francis, 1999 and 2001). The National Curriculum appears to have *postponed* the gender differentiation of subject choice and achievement, rather than eradicating it. At the post-compulsory stage, boys and girls have continued to choose the subjects traditionally associated with their sex. Furthermore, despite the common curriculum, the scope for gender differentiation in science and technology lower down the school remains in several ways. Firstly, some GCSE option choices are made in Year 9, at age thirteen, where courses to pursue for the following two academic years leading to the GCSE examinations are selected. At this stage, some subjects can be dropped and others chosen to replace them. For example, in 1999/2000, girls were only 40% of those attempting GCSE Information Technology, but 94% of those taking Home Economics (DfES, 2001). Secondly, all pupils are required to take a Design and Technology course at GCSE level, and girls are achieving well in this subject, with 59 per cent of girls achieving grades A* to C, compared with only 43 per cent of boys in 1999/2000 (DfES, 2001). Within GCSE 'design technology' however, there are different course options available (food, textiles, materials, electronics and so on) and girls and boys are choosing differently. National disaggregated data on technology options is unavailable to date, but my own data set shows that girls were 94% of those taking textiles technology and 79% of those taking food technology, but only 13% and 22% of those taking electronics and product design respectively (see Chapter Four).

Finally, there are gender differences in pupil entries to the GCSE 'separate sciences' examinations. The majority of pupils in comprehensive schools in England and Wales take the combined science award (Double Award) and national statistics show that the sexes are entered for this examination in roughly equal proportions. However, many schools offer more able pupils the chance to enter for all three sciences as single GCSEs. More boys than girls are entered for these more prestigious examinations, which give pupils a greater opportunity to achieve more GCSE passes and are considered by many teachers to be a better preparation for A-level study of a science subject (Warrington and Younger, 2000; Bell and Forster, 2001). According to table 4 below, in 1999/2000, girls were only 39%, 40% and 42% of those entered for GCSE physics, chemistry and biology respectively:

Table 4: Girls as a percentage of those attempting GCSEs in SET-related subjects, 1999/2000

Single Award Science	49.6
Double Award Science	50.2
Physics	38.7
Chemistry	40.2
Biological science	41.6

Source: DfES Statistics of Education: Public examinations GCSE/GNVQ and GCE/AGNVQ in England 2000. Extracted from table 7a, 'GCSE achievements of 15 year old pupils in all Schools by subject group and grade group, by the end of 1999/2000 (England)'.

Girls' lower entry to these examinations is surprising, given that national statistics show that where girls are entered for these subjects, they are generally outperforming boys. This gender difference in entries suggests that despite evidence of girls superior achievements, teachers responsible for deciding which pupils should study for and enter single-sciences examinations are over-estimating boys abilities and under-estimating girls' (see Warrington and Younger, 2000).

It is reasonable to suggest that the National Curriculum has to an extent, improved equality of *access* to science and technology, but not equality of *outcome* (Brown, 2001). In actual fact, the National Curriculum has had a limited impact on gender inequalities in terms of female participation in scientific and technological fields beyond compulsory education. Although girls have outperformed boys in GCSE examinations, 'they still feel alienated from traditionally 'male' subjects such as science' (Warrington and Younger, 2000: 495) and they continue to drop these subjects once they are no longer compulsory. Both educational and occupational gender segregation remain. Brown (2001) concludes that despite improving equality of access, neither the Sex Discrimination Act nor the National Curriculum have made that much difference to the gendering of A-level subject choices. Despite the National Curriculum, therefore, educational and occupational choices remain strongly influenced by gender and girls and boys continue to study different subjects, particularly at the post-16 level. Table 5 below illustrates girls' minority position in the physical sciences, mathematics and technology, but their over-representation in biology and languages.

Table 5: Girls as a percentage of candidates aged 16-18 taking GCE A-levels in selected subjects in all schools and colleges in England 1999/2000

Physics	22.7
Technology	28.5
Maths	37.6
Chemistry	48.3
Biological Science	61.6
English	70.4
French	70.8

Source: DfEE Statistics of Education: GCSE/GNVQ and GCE A/AS Level & Advanced GNVQ Examination Results 1999/2000 - England. Extracted from table 15: 'Success rates of GCE A-level and AS examination candidates of all ages in selected subjects in all schools and colleges in 1999/2000'.

The relationship between subject choices and aspirations towards engineering

Given the obvious gains females have made in education, many UK policy initiatives for tackling female under-representation in technology and science no longer view formal sex discrimination or lack of female aptitude in science as the primary obstacles to participation. Rather, explanations have shifted from a focus on girls' and women's *exclusion* to their *self-exclusion* from these areas through their educational and occupational 'choices'. This shift in some ways brings us full circle, reversing the focus of explanation back from structural factors to individual ones, mirroring earlier approaches, which are focused on girls and women.

A key explanation for low female participation in engineering then is that girls' opportunities to take up engineering careers are blocked by their low participation in maths, technology and the physical sciences at A-level stage. However this argument rests on the assumption that if students like these subjects and choose to study them, they will also choose engineering careers. Certainly maths and physics A-level are pre-requisites for many engineering degrees, but if it became compulsory for all girls to sit these subjects, would they then flock to engineering degrees in large numbers? Some commentators are doubtful and have problematised the assumed link between educational and occupational choices, as it ignores a host of other factors. For example, in their research on women's position in science in the US, Hanson et al. (1996) agree that women's participation in science occupations is dependent on their participation in science education, but that this relationship is not a simple one (1996: 286). They assess the link between education and the labour market, concluding that 'gender-inclusive' education systems, that is, those that promote access to the study of science amongst females, nonetheless do not guarantee high representation of women in science education and occupations. For Hanson et al. (1996), gender-inclusive education is necessary, but not *sufficient* to change occupational inequalities between the sexes. This also appears to be the case in the UK, where, as previously mentioned, the National Curriculum laid the foundations for equal access to the curriculum, but this has not lead to equal outcomes. Girls are no longer formally barred from studying science and technology at school, nor are they prevented from progressing to engineering education and employment, yet they continue to be under-represented in these areas. The evidence shows that girls do continue to opt out of the physical sciences and technology subjects in larger numbers than boys once they are free to do so. Nevertheless, the recent gains that women have made in relation to their participation in occupational fields such as medicine, dentistry and veterinary science show that many girls *are* capable of achieving in the 'three sciences' at school, although their participation in physics remains low. Perhaps therefore, attention should be paid, not only to why so many girls avoid these subjects, but also to the reasons why those females who *do* study them continue to reject careers in engineering and the physical sciences. (Lightbody and Durndell, 1998). This suggests that the relationship between choosing the sciences and technology for advanced study and choosing engineering as a career needs further investigation. Although young people's opportunities to pursue careers in engineering importantly depend on studying the relevant subjects, the particular reasons that engineering is rejected as a career choice also need further exploration.

The subject choice process

As mentioned earlier, many now argue that the subject choice process at school is at the root of women's exclusion from science (and by extension, engineering) (Birke, 1986; Colley, 1998). Important educational choices are made in the last year of compulsory schooling, when those pupils continuing with their education select the subjects they will study for A-level and other types of qualification. It is argued that the subject choices made at this stage are likely to have the greatest impact on young people's career choice and the opportunities available to them (Lightbody and Durndell, 1993). This is significant for undergraduate engineering, which depends on the selection of mathematics *and* physics at the A-level stage. As already mentioned, at A-level, girls opt for these subjects (both separately and in combination) in lower proportions than boys, so the subject choice process is a crucial 'filter' for pupils of both sexes, but especially girls, away from engineering.

For this reason, there is a need to continue to explore the reasons behind young people's subject choices and preferences. While doing so, however, it is necessary to avoid on the one hand, an overly deterministic perspective which tends to view girls' and women's attitudes and decisions as 'misguided', and on the other, an overly voluntaristic perspective which overstates the role of agency in 'choice'. To achieve this, the notion of 'free' choice must be problematised, by locating young people's subject choices within the wider social and educational contexts in which they are made. The questions are: what are the mechanisms by which gender is operating to produce differential choices for girls and boys in the physical sciences and technology? And to what extent can we link these choices with the subsequent gendered take-up of engineering careers?

The sex-stereotyping of academic disciplines

Earlier in the Chapter a range of perspectives were presented to show the ways that engineering has come to be widely perceived as a 'masculine' occupation. It was argued that engineering is considered masculine for a variety of reasons, including the historical 'gendering' of technology and science, the sexual division of labour and the consequences this has for cultural expectations, and the motivations, attitudes and choices of individuals. With the erosion of formal sex discrimination and the evident gains girls have made in academic achievements, the conclusion reached by many, including the Equal Opportunities Commission (EOC), is that sex-stereotyping is now the primary remaining cause of occupational gender segregation. Sex-stereotyping is defined by the EOC (2001d: 1) as 'making assumptions that women and men should play different roles in society'.

The perception that engineering is masculine has been blamed by the Equal Opportunities Commission on harmful stereotypes, particularly the widespread sex-stereotyping of occupations. They argue that sex-stereotyping denies individual aspirations and limits young people's career choices and opportunities, leading them to opt for traditionally 'male' and 'female' subjects at school, therefore blocking their entry to jobs traditionally done by the other sex. Tackling this problem is high on the agenda for the Equal Opportunities Commission, who launched their national campaign "What's Stopping You?", in October 2001, in an attempt to challenge sex-stereotyping and widen young people's educational and occupational choices.

But how exactly are these occupational sex-stereotypes perpetuated and how do they link to the sex-stereotyping of educational subjects? One argument is that different subjects and fields of study have been historically linked to roles and traits traditionally expected of men and women. For example, subjects such as science and mathematics are concerned with objects, rationality and logic - traits traditionally seen as masculine, whilst subjects about people, or those linked to the feminine stereotype of wife and mother are seen as 'feminine'. Hence these subjects are 'sex-stereotyped' (Whitehead, 1996: 148).

Sex-stereotyping and subject choice

In early research on why girls are less likely than boys to choose scientific subjects, Weinreich-Haste (1981) investigated the sex-stereotyping of different fields of knowledge amongst young people. Adolescent school pupils and university undergraduates were asked to rate a number of subjects on a variety of scales: masculine-feminine, hard-soft, science-arts, complex-simple, abstract-concrete, practical-theoretical and intellect-based-feeling-based (1986: 113). Weinreich-Haste found that the 'craft' subjects, that is, cooking, typing and woodwork (as they were called in those days) were the most strongly 'sex-typed' subjects and also that physics, mathematics and chemistry were the most masculine academic subjects (1981: 220). Correlations between the ratings on the various scales led Weinreich-Haste to conclude that there was a 'constellation of beliefs' about scientific subjects, which expressed a view about the 'fundamental masculinity of science' (1986: 115), in that science was masculine, hard, complex, abstract and based on thought rather than feeling. Weinreich-Haste draws attention to the fact that girls perceived science as difficult and that they also saw complicated and difficult things as masculine (1981: 221). Whilst boys, more than girls, found difficult things interesting and 'feminine' things boring, girls more than boys, regarded things concerning feelings and people as simple and easy (1981: 221).

Weinreich-Haste (1986) claimed that the sex-stereotyping of school subjects as 'masculine' or 'feminine' is tied to a wider set of beliefs based on binary forms of thought, which are also hierarchical and privilege the masculine side of the dichotomy. The argument is that those subjects considered masculine are also considered more valuable, more difficult, more scientific and about things (as opposed to about people). In contrast, those subjects considered feminine are at the same time considered less valuable, easy, unscientific and about people (Weinreich-Haste, 1986; Archer and Freedman, 1989). Other studies have also found that some subjects foundational to engineering, for example mathematics and the physical sciences are considered the most difficult (Lips, 1992, Stables and Stables, 1995). It would therefore follow that those who consider themselves less 'able' will be discouraged from continuing with these subjects. Females in particular are likely to be affected, since there is evidence that they lack confidence in their abilities in science and maths relative to males (Kelly, 1987a; Walkerdine, 1989; Stables and Stables, 1995; Kimball, 1995) and are more likely to avoid those subjects considered difficult (Kelly, 1987a; Stables and Stables, 1995).

At around the same time period as Weinreich-Haste's research, Ormerod (1981) investigated sex differences in science subject preferences, choices and attitudes amongst 13-14 year olds in single sex and co-educational schools. This study was carried out before the implementation of the National Curriculum (1988), when it was possible for pupils to drop science subjects after the third year of secondary education, at the age of fourteen. Ormerod found that for all the sciences and mathematics, 'the preferences of co-educated boys and girls were further apart than those of single-sex educated boys and girls' (Ormerod, 1981: 102). As a result of these findings, Ormerod developed the 'polarisation hypothesis', which stated that adolescent boys and girls being educated together will use subject preference and subject choice to assert their gender identity (1981: 102). When this 'polarisation hypothesis' was tested, the picture became more complicated. It was found that girls' subject *preferences* did not match their subject *choices* to the same degree as boys. In actual fact, a significant number of girls were dropping subjects they liked (such as physics and chemistry) and taking subjects they disliked. This led Ormerod to suggest that the option system was more suited to boys' pattern of preferences than that of girls. It was also suggested that girls might be put off physics and chemistry because they are male dominated subjects, that they might have received negative advice from teachers, parents and peer groups and that they might be put off by the belief that these subjects are difficult (1981: 102). Ormerod found that of the science subjects, the boys liked chemistry best, then physics, then biology. Girls liked biology best, then chemistry, then physics. Echoing a theme also raised by Weinreich-Haste, Ormerod also found that girls subject preferences are more strongly related to their perceptions of subject *difficulty* than are those of boys (1981: 103). Girls were less likely to prefer subjects they believe are difficult and there is evidence from more recent studies that physics and chemistry are seen as more difficult than other subjects (Stables and Stables, 1995). For Ormerod, this could partly explain girls' under-representation in these areas. He warned that the (then) trend towards more co-education would lead to further gender polarisation in subject choices, with even fewer girls choosing mathematics and the physical sciences in the future. He also believed that fourteen was an inappropriate age to be making subject choices, because of the influence of gender identity development on these choices, especially in co-educational schools, and for this reason recommended a compulsory science education up to the age of sixteen. This, of course, came about a few years later with the advent of the National Curriculum in 1988, discussed earlier in this Chapter.

Archer and Freedman's (1989) study of sixty A-level students in tertiary colleges built on Weinreich-Haste's earlier work on the role of sex stereotyping as an explanation of female underachievement in science and mathematics. They set out to test her theory that there is a cluster of other attributes associated with 'masculine' when academic disciplines are rated. Like Weinreich-Haste, they asked the students to rate a set of academic disciplines on a variety of dimensions, although theirs was along seven point scales to include a neutral point, rather than the six point scales which had been used by Weinreich-Haste. Following Weinreich-Haste, Archer and Freedman used masculine-feminine and science-arts dimensions, but added to these difficult-easy, interesting-boring, useless-useful and simple-complicated (Archer and Freedman, 1989: 307). They used one-sample t-tests to determine whether the ratings were significantly different from the neutral point on the scales. They found that engineering, physical sciences and mathematics were rated as significantly masculine, whereas English, biology, psychology, French and sociology were rated as significantly feminine. They also found that there was no effect of the sex of the rater on the results (1989: 306).

In their survey of first year A-level students in a tertiary college, Stables and Stables (1995) investigated gender differences in students' A-level subject choices and their perceptions of A-level subjects. They found gender differences in the uptake of subjects, finding that girls were more inclined to subjects with a heavy language demand, whereas boys were found in the more quantitative subjects. They also found gender differences in career aspirations, although less than they had found evident when researching slightly younger students. Girls were more likely to report that they had received advice on subject choice than were boys. In common with the other studies mentioned thus far, subject difficulty/easiness was a factor which emerged in Stables and Stables' study. This was found to have a gender dimension in that girls were more inclined to choose subjects seen as easier, which in this sample, were the 'human' sciences, defined as sociology and biology. Stables and Stables conclusion was that one of the main reasons for the gender differentiation in A-level choices was that girls lacked confidence, despite the fact that overall they were better qualified than the boys.

Whitehead (1996) examined the relationship between subject choice and the perception of school subjects as 'masculine' or 'feminine' amongst Year 13 pupils in mixed sex comprehensive schools in England and Wales. To measure pupils' perceptions of subjects, she asked respondents to indicate which subjects they thought boys or girls were best at. To elicit information on their subject choices, the pupils were asked to indicate which A-level subjects they were studying. Whitehead found that there were no significant differences between males and females in their perceptions of gender and subject ability. The majority of pupils believed that both sexes were equally good at most of the subjects on the list. Where stereotyped views were held, the stereotypically masculine subjects were economics, mathematics and the physical sciences and the stereotypically feminine subjects were modern languages (1996: 154). Whitehead had set out to test the hypothesis that pupils who held sex stereotyped attitudes towards occupations and sex roles and who saw themselves conforming to traditional notions of masculinity and femininity would be more likely to choose sex-appropriate subjects. Whitehead found her hypothesis confirmed in the case of boys but not for girls. The girls' choices showed less bias than boys, who were concentrated in the stereotypically masculine subjects, whereas girls were spread more evenly than boys over the range of subjects. One conclusion she came to was that 'it is not so much that girls are under-represented in mathematics and the physical sciences, but that boys are greatly *over-represented*' (1996: 155, emphasis added). Boys with strongly sex-stereotyped views were more likely to choose sex-appropriate subjects, whereas girls doing 'feminine' subjects did not on the whole, conform to stereotypical notions of femininity (1996: 159).

In a more recent study of perceptions of gender, subject preferences and subject ability, Francis (2000) asked 14-16 year old pupils to rank school subjects in terms of both their most and least favourite. She found some differences to the findings of previous studies in the pupils' ranking of their favourite subjects, but a more traditional pattern was found with the least favourite subject rankings, in that girls liked maths and science least. She also asked the pupils whether male and female students have the same *ability* at different subjects. Francis used a form of discourse analysis to analyse the pupils' responses, within which she was able to identify a number of competing narratives, or 'discourses'. Perhaps surprisingly, she found that the most commonly expressed view was that girls were better at some or all subjects than boys. This attitude could be taken to indicate a shift to greater equality for girls, but Francis warns that this 'discourse of individual opportunity' tends to conceal the continuing gender dichotomy at the post-compulsory level (Francis, 2000: 47).

A key conclusion shared by many of these studies is that young people's educational subject preferences and choices are influenced by the sex-stereotyping of disciplines as masculine or feminine. The argument is that the physical sciences, technology and mathematics are widely considered masculine areas, alienating girls (and indeed, many boys) from these subjects at school. Perhaps what needs teasing out further in many of these studies, however, is exactly *why* females or males should be so unwilling to study a subject traditionally associated with the other sex? Ormerod (1981), Kelly, E. (1981), Measor (1983), Thomas (1990) and Whitehead (1996) are amongst those who have made links between the stereotyping of school subjects, option choices, and the process of adolescent gender-identity formation. A key assumption shared by these writers is that young people face penalties in making non sex-traditional subject choices. In relation to physics, for example, Lewis (1984) has argued:

> girls are presented with a dilemma between maintaining their feminine identities or becoming closely identified with the study of physics (Lewis, 1984, cited in Thomas, 1990: 22).

Here then, the notion that young people's subject choices are mediated by the process of adolescent gender identity-formation is more explicitly spelled out, and along with it, the idea that girls and boys are constrained to choose those subjects considered appropriate for their sex, or face 'identity costs'. Both Mac an Ghaill (1994) and Epstein and Johnson (1998) have discussed the way that school subjects are used as a resource in the 'policing' of dominant definitions of young people's sexuality, within 'the presumption of heterosexuality' (Epstein and Johnson, 1998: 153). Therefore a student opting for a subject not typical of their sex can risk having their sexual and gender identity called into question.

The tendency for young people to choose sex-traditional subjects is not always seen as either a negative or passive process, however. Some of these writers have argued that subject choice is used *actively* by adolescent students, to negotiate and affirm their gender identities (Ormerod, 1981; Measor, 1983, Kelly, 1987c; Whitehead, 1996). This process also applies to gay and lesbian students, although the literature on this is more recent in emerging (for examples, see Mac an Ghaill, 1994 and Epstein and Johnson, 1998). In relation to females, Thomas (1990:81) for example, found that some of the women in her study who had attended single-sex schools had been actively encouraged by their teachers to study chemistry and physics. However, because they felt that studying these subjects threatened their femininity, they had rebelled by 'asserting traditional 'femininity'' and choosing non-science subjects.

The experiences of (heterosexual) females and males are not necessarily symmetrical, either. Whitehead's finding was that the girls in her study were less influenced by sex-stereotypes than the boys, leading her to conclude that there is a need to review established beliefs about girls and subject choice (Whitehead, 1996: 159). It is also important to keep in sight the differences between girls, noting that the consequences of making a non-traditional choice are not negative for all girls. Nor are all females 'deterred by symbolically masculine disciplines' (Hughes, 2001: 276). In her study of course choices in a further education college, Henwood (1996 and 1998) found that some female software engineering students felt they had benefited from choosing so-called 'masculine' courses, because these courses offer higher status than many of the traditionally 'feminine' courses. Other commentators have drawn attention to the ways in which young women employ strategies to challenge the masculine status of science and technology and find a place for themselves within it. Hughes (2001), for example, in her study of science students in Post-16 education, found that while femininity is less compatible with physical scientist identities than is 'hegemonic masculinity', some female students were able to negotiate the contradiction between being female and being a physical scientist by rejecting feminine subjectivity in favour of other aspects of their identity. Hughes illustrates this by giving the example of a female Vietnamese student, who, drawing on her ethnicity (as opposed to her femininity), distanced herself from 'the femininities of a dominant white culture'. In so doing, she generated a scientist subject position for herself by constructing herself as 'other' within a 'discourse of Vietnamese parental pressure to succeed' (Hughes, 2001: 283).

Chapter summary and conclusion

This Chapter has outlined conceptualisations of 'the problem' of women's under-representation in engineering education and occupations. It has compared a number of perspectives on 'why we need more women in engineering' and assessed various explanations for the general decline in recruits to engineering, including the arguments about the falling popularity of mathematics and the physical sciences as A-level choices and the negative image of engineering. The feminist contribution to understanding women's relationship to engineering was examined in more depth, and most crucially the argument that the 'masculinity' of engineering excludes women.

A major claim emerging from many of the studies described is that both school subjects and occupational roles are sex-stereotyped and that this is of considerable importance in leading girls and boys to make differential study and career choices. The Chapter showed how the sex-stereotyping argument is widely used as the main 'explanation' for the under-representation of females in engineering and that many policy initiatives have attempted to address this issue at the level of girls' attitudes and choices in secondary school, by encouraging them to choose from a wider range of options. The literature has also shown however, that this strategy has had limited success due to its voluntaristic theory of choice and the fact that it cannot account for the differences between women.

Of central relevance to this study are two primary hypotheses. The first is that engineering-related subjects (such as physics, mathematics and computer science) are widely regarded as masculine, discouraging many girls from pursuing them beyond the level of compulsory education and blocking their entry into scientific and technical occupations. The second hypothesis is concerned with the 'negative' image of engineering and in particular the assumption that engineering is widely perceived as a masculine occupation, again acting to exclude girls from pursuing it as a career. These two issues may or may not be connected. It is assumed that there is a close link between educational choices and occupational choices and certainly, it can be argued that girls' tendency to avoid maths, technology and the physical sciences in post-compulsory education makes them ill-qualified to pursue engineering degrees. But it may be naive to assume that if more girls became qualified in these subjects, we would automatically see more female engineers. Girls' superior examination results, and their increased entry to disciplines such as medicine which require 'prestigious' science qualifications suggest that many girls could compete for places on technological courses like engineering if they wanted to (Lightbody et al., 1997: 27). The point is, they clearly are not doing so. This would point to a need to consider discouraging factors in addition to the assumption that girls have more negative attitudes towards science and technology at school than boys. Perceptions of engineering also need to be investigated and assessed for their compatibility with career aspirations. For Lightbody et al. (1997: 35), the fact that girls are not choosing higher level studies in these disciplines suggests that 'female school leavers are aware of what they are looking for in the future and that careers in science and technology do not meet these criteria'. Given that fewer boys are now choosing engineering than in the past, it is also of interest to find out why this might be the case and whether there are any new areas of convergence between the sexes.

Certainly studies discussed earlier in the Chapter suggested that young women are well aware of the 'costs' and consequences for females entering the profession (Cockburn, 1985; Carter and Kirkup, 1990; Lightbody and Durndell, 1996a). One such cost is the perceived incompatibility of careers like engineering with women's projected family roles (Lips, 1992). Arguably, girls are less inclined to choose jobs they believe will make family life difficult, of which engineering, with its long hours culture, is one. Other studies have found that females are more inclined than males towards careers perceived to offer a higher level of social contact (Lightbody et al., 1997) and that engineering is typically not perceived to offer this. Rather engineering is often perceived in narrow terms to be primarily about tools, machinery and hardware, divorced from the social, economic, political and ethical spheres (MacKenzie and Wajcman, 1999) and the stereotypical scientist typically seen as 'asocial' and 'task orientated', rather than people orientated (Lips, 1992). Linked to this is the argument that while young women more than young men are attracted to careers which 'help people' (Foskett and Hemsley-Brown, 1997), technology and science may not generally be presented in schools in terms of their 'humanitarian' or socially beneficial applications (Whyte, 1986; Michel, 1988). There is also evidence to suggest that females have less confidence in the institutions of science and technology than males, and are also more likely to observe the more negative and 'harmful' effects of engineering, such as those relating to health risks, pollution and warfare (Fox and Firebaugh, 1992).

The differential take-up of subjects at school forms a major background to this research, which investigates the choices and attitudes of 16 to 17 year-old students in their first year of post-compulsory education in coeducational secondary schools. The research assesses the evidence for sex-stereotyped attitudes amongst these students towards subjects of study at school, and also investigates the extent to which engineering is stereotyped as a masculine occupation. The research will examine the degree to which the students' attitudes towards engineering-related subjects, namely the physical sciences, mathematics and technology, shape their attitudes towards engineering as a career. It will also examine the kinds of things the students are seeking from their future careers, and the extent to which engineering is perceived to offer these. The responses of male and female students will be compared throughout, for differences and similarities. In so doing, the research aims to identify some barriers to participation in engineering and separate those that may be common to both sexes from those that may affect females in particular. Chapters Three, Four and Five, present the empirical findings, but before this, Chapter Two will discuss the methodological approach to the research and the methods that were used to achieve these aims.

CHAPTER TWO:

Approaches to understanding and explaining young people's attitudes towards engineering

Introduction

This chapter describes the methods used in the study and provides a discussion of methodological issues. The chapter begins with a brief outline of the study before situating it in its methodological and theoretical context. Following this, there is a discussion of how the hypotheses were derived from the literature, how these were operationalised into more concrete measures, and a description of the study population. Each of the two research approaches used in the study is then described and justified, with some discussion of the methodological implications of each. The chapter closes with some reflections on the compromises that are required between the 'ideal' project and practical limitations, and the methodological and ethical implications that follow from such compromises.

A brief outline of the investigation

A cross-sectional, mixed-method, two-stage study design was used to collect data from two cohorts of first-year sixth formers (Year 12 students) attending co-educational comprehensive schools in Plymouth and Bristol. Qualitative research was undertaken at the outset, using focus group interviews to explore relevant topics derived from a broad social scientific literature focusing on the way gender impacts on the subject choices and career aspirations of young people in secondary school. The main purpose of the group interviews was to develop a deeper understanding of the issues from the perspectives of the students themselves and study the collective construction of meaning within the groups (see Bryman, 2001). The findings from these interviews were used to generate hypotheses and help to construct self-completion questionnaires (Barbour and Kitzinger, 1999), in which items could be framed in the students' own language and factors of salience to them could be prioritised. The questionnaires were used to collect data from a larger sample of students in the following year's Year 12 cohort.

In both the interviews and the questionnaire, information was collected on three broad topics. The first section covered the students' A-level subject choices, their enjoyment of subjects and their perceptions of subjects along various dimensions. The second section dealt with the students' career aspirations and factors they considered desirable in a job. The third and final section covered students' perceptions of engineering and their intentions towards engineering as a career (copies of the interview schedule and the questionnaire can be found at Appendices I and IV).

The broad hypothesis underpinning the study was that engineering and the school subjects relating to it have a masculine image that discourages girls and many boys from choosing it as a career. The main aim of the research was to assess the extent to which gender acts to structure choices in engineering, science and technology within the context of co-educational secondary education and a central question was "why is it that young people do not choose engineering careers, and how does this differ for females and males?". Having provided a brief outline of the study, the next section of the chapter will situate it in methodological context, beginning with some definitional discussion of what is meant by methodology.

Defining methodology

The term 'methodology' is not used in any uniform manner within the social science literature, making it difficult to define. In some writings, methodology is treated as synonymous with philosophical positions on the production of knowledge, whereas in others it is used to refer to actual research techniques, or 'methods'. Commentators have pointed out that the terms 'methodology' and 'method' are frequently conflated, or used interchangeably in research methods literature (Bryman, 1984: 76; Blaikie, 1993: 7; Sarantakos, 1993: 30). A more accurate understanding of methodology places it at the intersection between philosophy and method. *Methodology* is concerned with how research should or does proceed (Blaikie, 1993: 7) and with criteria for assessing its quality. *Methodologies* are particular approaches for studying the social world, which are underpinned by certain philosophical assumptions on the nature of social reality (ontology) and what can count as knowledge of it (epistemology) (see Adams and Schvaneveldt, 1991: 36, Blaikie, 1993: 131, Williams and May, 1996: 10).

Philosophical foundations of research

During the long history of social research there have been two dominant and often opposing philosophical positions on the study of the social world. A variety of terms have been used by various authors for these two positions, which are perhaps most often known as 'positivist' and 'interpretivist' (Bryman, 2001). A key distinction between the two positions is that positivism has an ontological view of the social world as external to social actors and advocates a natural science epistemology to gain knowledge of it. That is, that the social world should be studied by applying the same methods as those used to study the physical world. In contrast, interpretivism is premised on the ontological assumption that the social world is 'something that people are in the process of fashioning' (Bryman, 2001: 4). For interpretivism, the social world is different from the physical world, because human beings *interpret* the social world and act on the basis of the meanings they attach to their behaviour and that of others. Therefore the social world needs to be studied with different approaches from the physical world (Bryman, 2001: 13).

Two distinct methodological approaches to the study of the social world have resulted from the philosophical differences between positivism and interpretivism, the former aiming for *explanations* of social phenomena and the latter on *understanding* them. Positivist social science has aimed for explanations of human behaviour in terms of cause and effect, the discovery of social 'laws' and generalisation to large numbers of people. In contrast, interpretivist social science is characterised by a commitment to seeing through the eyes of the people being studied in order to understand human behaviour, preferably within the context in which it takes place (see Hughes, 1990, Hammersley and Atkinson, 1995 and Bryman, 1988). Traditionally, positivism has been linked with experimental and survey methods, theory-testing, measurement and quantitative analysis, whereas interpretivism is linked with the use of qualitative methods and providing 'rich' descriptions. Due to each of the two epistemologies' historical associations with different methods, the two methodological approaches attached to them are commonly referred to as 'quantitative' methodology and 'qualitative' methodology.

Methodological diversity

As a result of the different philosophical positions underpinning them, traditionally quantitative and qualitative methodologies have been seen in terms of an irreconcilable dichotomy – what Bryman (1998 and 2001) has termed the 'quantitative-qualitative divide' and Tashakkori and Teddlie (1998) have termed the 'paradigm wars'. A famous exception to this is perhaps Max Weber, who attempted to reconcile the goals of positivism and interpretivism within his methodology, although some writers imply that the latter is given precedence (see for example, Bryman 2001: 14). Those subscribing to the 'incompatibility thesis' have claimed that it is not possible to mix methodologies, as the philosophical differences that underpin them are irreconcilable (Bryman, 1984). However, more recently, other commentators have claimed that there is much more overlap between the two methodologies than previously implied and that it is misguided to treat quantitative and qualitative research in this dichotomous manner (see Bryman, 1988, 1998 and 2001). Typically, qualitative research has been associated with a concern for subjects' interpretations, but there is no reason to suppose that quantitative research cannot share this goal (Bryman, 1998). The supposed fit between 'constructivist' approaches and qualitative research is not necessarily the only fit. For example, it is possible to employ quantitative attitude measurement techniques to demonstrate regularities of meaning that do not have to be understood as static realities, but rather as reflections of socially constructed meanings within specific contexts.

Increasingly, it is argued, methodological diversity is becoming the dominant approach of many researchers (Bryman, 2001). Realism, for example, is a philosophical position that is able to bridge some of the gaps between the epistemological and ontological assumptions traditionally associated with the methodological divide. At the philosophical level, realism is compared with empiricism on the one hand and idealism on the other. The former position tends to reduce knowledge of the social world, while the latter plays down the existence of any social reality other than agents' understandings of it (Williams, 2003). One way in which realism can attempt to bridge this divide is to support an ontological position in which social phenomena can be perceived both as socially constructed *and* simultaneously having a reality that is external to individuals (see Olsen, 2002, later in this chapter). Williams (2003: 1) argues that 'in sociology, empiricist explanations of the social world are largely discredited and some form of realism is now commonly favoured by social researchers'. The model of realism informing this study will be discussed in more depth later in this chapter.

The increased acceptance of methodological diversity also extends to feminist research, where, until relatively recently, quantitative and qualitative research were also considered irreconcilable, although the emphasis of the argument was slightly different. Formerly, interpretivist methodologies were considered the most 'feminist' approach. This is because the quantitative methodology was seen to embody masculine values, such as autonomy, separation, distance and control (Jayaratne and Stewart, 1991: 89). In the early 1980s, many feminists debated whether certain methodological norms and techniques, particularly very 'structured' approaches, were dishonest or harmful to participants. In *Interviewing Women: A contradiction in terms?*, Oakley (1981) famously criticised survey interviewing for its requirement of researcher detachment, believing that the interviewer 'takes' from the interviewee without giving anything back, which she argued was 'morally indefensible' and incompatible with a feminist approach to research (Oakley, 1981: 41). Many feminists agreed with this view and it became widely accepted that there was a tension between 'traditional' methodological procedures and the goals of feminism (Jayaratne and Stewart, 1991). For this reason, an 'orthodoxy privileging qualitative methods' developed (Maynard, 1998: 128). In recent years, however, feminist researchers have become more amenable to using quantitative as well as qualitative methods (Oakley, 2000, Bryman, 2001: 454). A famous example of this comes from Oakley herself, who, in her landmark 1998 paper in the journal *Sociology* admitted she had taken a 'journey' from 'a defence of qualitative methods to a recognition that what feminism and social science both "need" is a more integrated approach' (Oakley, 1998: 725). The research described here began from the position increasingly taken by many feminists. This is that the debate about qualitative and quantitative methods is now 'sterile and based on a false polarization' (Jayaratne and Stewart, 1991: 85) and that any method can be used for feminist purposes (see also Harding 1987; Reinharz, 1992; Kelly, Regan and Burton, 1992; Eichler, 1997).

Both qualitative and quantitative approaches were taken in this study, which could be described as 'mixed-method' research (Punch, 1998). However, the way the two approaches were combined in this study needs further clarification, as there are many ways of combining quantitative and qualitative research (Bryman, 2001; Punch, 1998). These can include for example, full 'integration' of the two approaches, 'linking' them, or 'adding one approach on to the other' (Punch, 1998: 246). There are also strategies in which different approaches can be 'triangulated' at several levels. Denzin (1989: 234), for example, identifies 'strategies of multiple triangulation' at the levels of data, investigator, theory and method. In this study, the qualitative and quantitative phases of data collection were not designed to 'triangulate', or be simultaneous and fully integrated strategies, rather they were intended to complement each other by each offering different strengths (see below).

Advantages of combining qualitative and quantitative research

Many arguments for combining qualitative and quantitative approaches are made at a general level (Punch, 1998). For example, Berg (1989: 4) has argued that combining different 'lines of sight' in this way enables researchers to obtain 'a better, more substantive picture of reality'. Brewer and Hunter (1989) agree, claiming that combining methods enables us 'not only to gain their individual strengths, but also to compensate for their particular faults and limitations' (1989: 17). Certainly a strong argument for using more than one approach is to increase the scope, depth and power of the research (Punch, 1998: 243). As Punch (1998: 246) points out, however, the reasons for combining the approaches should also be considered in the context of the specific research.

Using the interpretative approach offered a 'micro' investigation of the interaction of the students within the context of a focus group. The advantages of this method are that it allows an 'insider' perspective so that issues can be seen 'through the eyes of the participants'. This made it possible to explore the students' own understandings and constructions of engineering, as opposed to imposing those derived from researchers' categories. This was especially important and relevant, given that one of the factors affecting the image of engineering is that the identity of British engineering remains highly contested (Smith and Whalley, 1995). Previous studies have found, for example, that young people of secondary school age say they know little about engineering (MORI,

2001) and that popular understandings of engineering have 'mis-defined' it (Glover and Herriot, 1982; Smith and Whalley, 1995). Using the interpretative approach at the outset of the investigation allowed rich insights into how young people themselves define engineering, and the images it brings to mind for them. The data generated with this method then helped to prepare the ground for the quantitative research, in that many of the students' own constructions of the issues were used to design questions for the survey. Framing questions in the students' language, as opposed to researcher's language, was an attempt to make the survey items easier to interpret, thus helping to increase the validity of the self-completion questionnaire as a measuring instrument.

The strengths of the quantitative survey research were that it was able to provide a more 'macro' picture of young people's choices and attitudes towards engineering. This method can illuminate larger-scale patterns of behaviour, choices and attitudes and demonstrate the extent to which they are present and distributed unequally within a population. With this technique it is also possible to demonstrate relationships between variables, to show, for example, the way gender interacts with other variables to produce unequal outcomes in relation to participation in engineering and the physical sciences. Depending on the quality of the sample, it is also possible with this method, to make generalised statements beyond the population in the sample (for discussion and defence of quantitative methods in feminist research see Epstein Jayaratne, 1983; Jayaratne and Stewart, 1991; Reinharz, 1992; Oakley, 1998).

Although the above discussion has drawn out some of the contrasts between the qualitative interview and quantitative survey approaches, Bryman (1988 and 2001) reminds researchers that the differences between qualitative and quantitative research are often overstated. It is often assumed, for example, that qualitative research 'cannot be used in order to test theories in the manner typically associated with the model of the quantitative research process' (Bryman, 1988: 172). However, in the context of this study, both the qualitative and quantitative approaches were employed within a theory-testing framework in which evidence was sought with which to confirm or disconfirm hypotheses derived from previous research. Conversely, some commentators have pointed out that it is often claimed that quantitative research is not concerned with meaning in the way that qualitative research is (Marsh, 1982; Bryman, 2001). However in this study, not only were many of the survey items derived from the preceding focus group participants' meanings, but the attitudes measured in the survey are treated, not as fixed attributes of individuals, but as indicators of the underlying construction of meaning. In this sense, both the focus groups and the survey share a concern with exploring and describing the students' meanings and understandings in a given context. A fuller description of the actual methods used and the methodological issues they raise will follow later in the chapter.

A realist model of research

In using both qualitative and quantitative approaches, this study then combines aspects of both interpretivist and 'positivist' epistemologies within a feminist theoretical framework. As alluded to earlier in the chapter, it may be more accurate to describe the study as *realist* in overall orientation. Realism shares with interpretivism the goal of understanding, but offers an approach that goes beyond this to produce an understanding of human action that also takes into account constraining and enabling social structures and mechanisms (Wainwright, 1997: 1268). A realist perspective shares with positivism a natural science approach, a desire to produce explanations, and an ontology that accepts there is a reality external to actors. However, it differs from positivism in that it also accepts the view that there are deep structures underlying behaviour that may not be directly observable (Bryman, 2001: 13). At its broadest, a realist social science can be defined as one that aims to explain social behaviour 'with reference to underlying structures and mechanisms' (Blaikie, 1993: 98).

Middle-range realism

More specifically, a 'map' for this study was provided by 'middle-range realism', a methodology outlined by Pawson (2000), which he has developed from Robert Merton's (1968) leading work on middle-range theory. Middle-range realism has an ontology that assumes that 'social reality consists of overlapping strata', and actions 'only make sense (...) because of their location in the midst of the various layers of social reality' (Pawson, 2000: 294). What follows from this is that to explain social conduct, the researcher must understand peoples' actions within these layers of social reality, in other words, in *context*. As already mentioned, realism assumes some notion of underlying structure. The researcher is therefore required to identify the underlying processes, or 'mechanisms' that produced this social conduct. As Pawson puts it:

> What is 'real' about society is not only its 'events' and 'observables' but also the 'structures' and 'powers' of its objects (Pawson, 2000: 294).

Pawson outlines a framework, or model, for understanding a 'stratified reality' which comprises three key components: *mechanism, context* and *outcome* (2000: 295). A 'mechanism' might be understood as another term for a social process, or stucture. The search for such mechanisms needs to take place within particular *contexts*, as 'realists stress that all social action takes place in pre-existing contextual conditions and maintain that the culture, rules, norms, and power-balances therein will shape and reshape the consequences of any action' (Pawson, 2000: 297). The consequences then, are also the *outcomes*, which are the observed 'patterns', or 'regularities' that are found during the course of the research. In this particular study, an example of an outcome would be the differentiation between female and male students in relation to their participation in engineering careers. The emphasis in Pawson's model on the word 'outcome' is because the observed patterns are 'understood as *resulting from* the action of the underlying mechanisms in particular contextual conditions' (Pawson, 2000: 297).

In summary then, the model requires the researcher to 'postulate upon the *mechanisms* that account for particular *outcomes* in particular *contexts*' (Pawson, 2000: 299, my emphasis added). Pawson's model, referred to by himself as the 'CMO' model of explanation, is depicted in the following way: *mechanism* + *context* = *outcome* (Pawson, 2000: 297). Crudely applied to the study at hand, CMO would provide the following broad explanation of the 'problem' of low female participation in engineering:

> *the co-educational secondary school (C) is a site for young people's educational and occupational choices, which are structured by gender processes (M) to produce unequal outcomes for females and males in relation to engineering careers (O).*

In its current form this is, of course, a rather abstract statement, and would require further operationalisation to provide a more concrete explanation of events. One would be aiming, for example, to identify explicitly what the 'gender processes', or Mechanisms, were.

One criticism of the CMO model is that there can be a tendency for slippage between each of the three concepts. This means in practice it is not always easy to distinguish what might be a Context from what might be a Mechanism, or even a Mechanism from an Outcome. Sexual harassment for example, could be understood to be a Context in some circumstances and a Mechanism in others. Likewise, career choices might be understood as a Mechanism in some circumstances and an Outcome in others. Despite these limitations, however, the CMO framework is a helpful tool to guide and organise the research. A general strength of a realist approach is that it goes beyond mere empirical description of observable outcomes to explain how and why these happen, through an engagement with theory. A further strength of the model outlined here is its potential to address philosophical dualisms, such as that between universalism and relativism. Rather than asserting that there are universal laws determining social outcomes, the outcomes are explained as arising in particular contexts, which may be historical and local, and from particular mechanisms, 'the workings of which are always contingent and conditional' (Pawson, 2000: 298). It is also an attempt to bridge the gap between structure and agency, using propositions which combine both 'structural resources and the agent's reasoning' (Pawson, 2000: 298). It is therefore a position which accepts that 'mechanisms' can be both ideological (e.g. gendered attitudes) and material in nature (e.g. gender discrimination in school timetable organisation).

Realism and feminism

Importantly, realism can be compatible with a feminist approach to research and theory. As already mentioned, feminism is not a unified school of thought. A commonly used way of distinguishing between forms of feminism is to divide them into two broad perspectives: so-called 'modernist' feminism and 'poststructuralist' feminism (see Francis, 1999). This division reflects some of the ontological and epistemological differences between broad feminist approaches, and in particular the tensions between the 'modernist' assumption that we can represent independent phenomena reliably and the 'post-modernist' assumption that it is impossible to understand the social without simultaneously constructing it (Maynard, 1998). Realism, however offers a chance to reconcile some of these extreme positions, not least because some realist forms of explanation attempt to bridge dualisms such as objectivism-constructionism, universalism-relativism and structure-agency.

As regards the universalism-relativism dualism, a major challenge for feminism, as a movement committed to overcoming female disadvantage, is that it needs to hold on to at least a minimal form of universalism in order to make statements about 'women' as a category and describe their experiences, situations and so on. At the same time, however, feminism must acknowledge that 'woman' is not a universal category, in that gender is only one of many identities that can determine an individual woman's experiences and 'outcomes'. Realism, by offering an approach that is flexible enough to explain outcomes in terms of historical and cultural *context*, and viewing these outcomes as contingent and conditional, makes it more possible to account for the differences *between* different women in different circumstances. The structure-agency dualism poses another challenge for feminists attempting to produce explanations of female disadvantage. Explanations which purely emphasise the structural constraints upon women can be overly deterministic, inflexible and pessimistic, while, conversely, those which overstate the role of individual agency are overly voluntaristic. Henwood (1998: 36), criticising the polarised approaches used to understand women's position in engineering and technology, argues that

> we must overcome the individual-society dualism 'if we are to understand women's agency in their occupational decision-making without relying on notions of free choice and individual opportunity on the one hand, or, on the other, on the straightforward reproduction of pre-given gendered power relations (Henwood, 1998: 36).

Realism and the status of attitudes

This research is primarily a study of sixth formers' attitudes, but this is not to say that these attitudes are accorded the status of fixed characteristics of individuals, as they have been in traditional survey research. According to Williams (2003: 6), these kinds of assumptions have been 'criticised by "anti-positivists" for ignoring the meaningful reality of the agents researched'. Olsen (2002) has pointed out that one of the strengths of a realist approach is that we are able to maintain a position which, while perceiving social phenomena as social constructions, synonymously grants them a reality that is external to individuals. One of the tenets of realism then, is that 'measurement in survey research is an attempt to represent social reality, but that reality is not directly given' (Williams, 2003: 11). This is the assumption guiding this study, whereby the students' 'attitudes' are understood as indicators of underlying mechanisms.

In summary, a realist approach would allow for the view that beliefs and ideas, although social constructions, have 'real causal effects' (Olsen, 2002: 192). It would prescribe that young people's attitudes and choices must be placed in their social and historical context and that the 'masked social and personal factors that have caused the person to respond in that way' must be explored (Olsen, 2002: 192). The feminist dimension of the approach prioritises the importance of gender within this process.

How feminism shaped the research design

The debate about feminist research

The study then is informed by a realist ontology within a feminist framework. To say this is 'feminist' research is however, not unproblematic. Because feminism is such a diverse body of thought, 'much discussion has taken place as to whether there is, or should be, a specifically feminist approach to doing social research' (Maynard, 1998: 127). This debate has taken place at several levels including the ontological, epistemological and methodological, which are often conflated with discussions of method. Although the debate is not resolved, Maynard voices an increasingly popular view within feminism when she points out that the claim that there is such a thing as feminist research has 'more legitimacy in relation to methodology than it does to methods per se' (1998: 127). Eichler (1997) would agree, claiming that there are no *methods* that are distinctive to feminism, although there are examples of methodological postulates that 'capture a significant segment of feminist research' (Eichler, 1997: 13).

Eichler (1997: 10) claims that a minimal definition of 'feminist research' would be that which is concerned with the improvement of the status of women. While wanting to avoid lengthy debate on what constitutes feminist research, it can be argued that this investigation is feminist in the following main ways. First, the research begins from a feminist premise: that girls and women are disadvantaged in relation to their participation in engineering education and careers. Second, the research has a feminist purpose - to produce knowledge that can be used to improve women's relationship to engineering, technology and science. Third, the research is informed and guided by a feminist theoretical framework (although not exclusively so). Fourth, there is a focus on gender as the central analytical variable in analysis, although this is not to imply that others, such as social class, are not considered important.

Who is the research for?

The fact that this study began from a feminist perspective shaped the research design in a number of ways. First of all, a personal concern with female disadvantage in technology and science and a desire to know more about how this disadvantage is reproduced had led to the choice of research topic at the outset. Second, the existing body of feminist theory in the area provided the background to the study, helped to define and focus the research problem and to formulate the research question and the hypotheses. In their turn, the way the research question was formulated and the way the hypotheses were operationalised fed back into methodological decisions about how the data should be best collected and analysed. There was also the question about the overall purpose of the research. Who could stand to benefit from the insights gained from the project? Certainly, the Engineering sector might stand to gain more information about how the profession is perceived by young people generally. However the project primarily began in the hope that insights into the constraints upon young women's educational and occupational choices in relation to technology and the sciences could in some way contribute to the body of knowledge informing low female participation in engineering.

Choice of participants

Finally, feminist concerns also influenced considerations about which participants to research. Much research of a feminist nature has understandably focused exclusively on female participants with the aim of producing knowledge about women's experiences (Kelly, Burton and Regan, 1994). Although this research originates from a feminist concern with *female* exclusion from engineering careers, both males and females were the focus of this investigation. It was considered important to research males as well as females for several reasons. Kelly, Burton and Regan make the point:

> Whilst much feminist research focuses rightly on women, on creating knowledge about women's experiences, if our concern is to understand women's oppression we need to target our attention on the ways it is structured and reproduced. Feminist research focuses on how women's lives are constrained by the actions of men individually and collectively and the strategies girls and women find to resist, challenge and subvert. Studying women's lives as a feminist means that male dominance, masculinity and men are always part of the research (Kelly, Burton and Regan, 1994: 33).

The behaviour, attitudes and choices of most females are formed in social contexts in which males are present. There is evidence that in a number of ways the behaviour of males has implications for the behaviour of females. This is certainly the case for adolescent girls making educational and occupational choices within the co-educational school environment (Kelly, A. 1981; Kelly E. 1981; Whitehead, 1996). It is helpful therefore, to understand gender as a 'relational' concept (Walkerdine, 1989; Thomas, 1990), which describes the way in which 'masculine' and 'feminine' are commonly defined as opposite terms, so that to behave as a girl is, by definition, *not* to behave as a boy, and vice versa. The fact that gender is relational in this way has important implications for girls' behaviour, attitudes and choices, including those related to careers in technology and science. Therefore, to adequately understand the behaviour, attitudes and choices of females, it is necessary to understand those of males as well.

This study therefore set out primarily to find out more about the processes underlying female exclusion from engineering careers, but attempted this by also examining the factors discouraging males from engineering. It was assumed at the outset that there might be obstacles to participation in engineering that are common to both sexes but also, given that many more males than females participate, that there would be particular factors that affect females especially. It was hoped to be able to identify and separate those factors affecting both sexes from those affecting females in particular. It was hypothesised that the recent decline in male applicants to engineering courses may indicate a shift in the 'gendering' of attitudes and choices, perhaps with males becoming more like females in their attitudes towards engineering. Therefore it was considered important to note any *similarities* between males and females, as well as any differences between them.

The theory-research relationship

For at least four decades, feminists have been concerned with the 'problem of women and science'. Consequently, there is a well-established, extensive body of theory and research (largely, although not exclusively feminist) relating to the issue of the low participation of females in engineering. This study was informed by this body of theory, hence, the overall relationship between the theory and research in this study could be described as a *deductive* one (Blaikie, 1993), or a 'theory then research' approach (Nachmias and Nachmias, 1992, Walliman, 2001: 159), whereby hypotheses are derived from theory and data is collected to test the hypotheses. However, the study contains elements of both inductive and deductive strategies in that it returns to data gathered earlier in the research cycle in order to make sense of some of the later data.

This section has discussed some of the philosophical, methodological and theoretical issues shaping the research strategy and design. The next section of the Chapter addresses the way the research questions and hypotheses were derived from the theory, and how these were operationalised.

Refining the research questions

Chapter One showed that both feminist and 'non-feminist' literature have provided a theoretical background for the study. Whilst the feminist literature has mainly concentrated on the barriers to female-participation, the 'non-feminist' literature helped to identify factors which might operate to discourage males, or even both sexes, from choosing engineering as a career. The recruitment difficulties currently experienced in engineering are seen as part of a larger problem of negative images of science, engineering and technology jobs amongst young people (see for example, Parry, 2002; Curtis, 2002). From professional engineering journals emerged the widespread assumption that 'negative' images of engineering discourage young people from considering it as a career. This is a frequently discussed issue within the engineering sector and its associated media (see for example *Engineering First*, 1999; *New Civil Engineer* 2002b). This research set out in part, to assess this theory. The idea that engineering has a *negative* image is, however, a rather general one and needs further definition. Attitudinal studies have shown that several dimensions to the negative image of engineering can be identified. These involve negative stereotypes of both engineers as people and of engineering as a career. The range of perceptions and images relating to engineering include the views that it is boring, 'asocial', dirty, manual work, low status, low paid, old-fashioned and male-dominated (see for example Glover, 1980; Glover and Kelly, 1987; Macdonald, 1995; Woolnough, 1996; Foskett and Hemsley Brown, 1997 and Lightbody and Durndell, 1998).

The question is, for *whom* does engineering have a negative image? An obvious answer is women, since they are the 'missing half' (Kelly, 1981). The feminist perspective builds on these theories by considering them within the context of gendered social relations and structures. Do these various dimensions of engineering's image have differential effects on girls and boys? For example, the idea that engineering is *boring* or *low-status* may discourage both sexes to a greater or lesser extent, especially the brightest students

(Macdonald, 1995), but the fact that engineering is a *male-dominated* occupation is arguably likely to be much more off-putting to females than males. Indeed a major explanation for female avoidance of engineering careers is that engineering, for a number of reasons is stereotyped as a job for males. However, the relationship between the gender-stereotyping of engineering and its rejection by females may not be a simple one, and it is possible that the 'masculinity' of engineering is a deterrent to many males as well as females. Furthermore, some women will be more attracted to engineering than others. Colley (1998) for example, has made the point that the 'gender-stereotyping' of subjects in school can be more of an attraction or deterrent to some pupils than to others. This argument also extends to gender-stereotyped jobs. In her studies of women's occupational decision-making, Henwood (1996 and 1998) found that some of the women chose careers in non-traditional fields because they believed they would offer them status and respect from others that they would not otherwise receive if they chose traditional 'feminine' occupations. These findings point to a need to be cautious about homogenising females and males and to not only look for differences between the sexes, but look for differences *within* each sex and for *similarities* between the sexes.

A further argument drawn from the feminist literature was that the subject choice process is key to female inequalities in science and technology occupations. This is because schoolgirls tend to opt out of 'the science pipeline' early (Hanson, 1996), thus blocking their future opportunities in careers like engineering (Whyte, 1986; Birke, 1986). Again gender-stereotyping has been blamed for this phenomenon. It is widely argued that science and technology are stereotyped as 'masculine' subjects, thus discouraging girls from continuing to study them once they are no longer compulsory (Weinreich-Haste, 1981; Kelly, 1981 and 1987; Whitehead, 1996). The main argument is that because of gender-stereotyping, girls hold negative attitudes towards science and technology and gendered option choice is the result. However, Lightbody and Durndell (1998) warn that girls' negativity towards science and technology should not be overstated. They cite evidence to suggest that boys as well as girls hold negative attitudes towards science, especially in adolescence. They also argue that the fact that females outnumber males in medicine, dentistry and veterinary science shows that many girls both choose and achieve in the sciences. For this reason, Lightbody and Durndell attribute the low participation of women in careers like engineering to negative perceptions of *careers* in the physical sciences and technology, rather than negative perceptions of these *subjects* per se.

The background literature had raised many questions. Given that females continue to avoid engineering careers and males are now less likely to consider engineering than previously, it seemed timely to re-visit some of these theories and find out if anything had changed. To achieve this required an investigation of young people's attitudes with some of the following questions in mind: Is it the case that young people have negative perceptions of science and technology as school subjects? Do perceptions of science and technology differ by sex? Are academic disciplines and occupations gender-stereotyped? What kinds of careers attract young people? What images of engineers and engineering are held? Are these images negative or positive, and for which students?

For the study as a whole, two primary research hypotheses were derived, as follows:

<u>Hypothesis one</u>:

> Engineering has a negative image amongst young people.

<u>Hypothesis two</u>:

> Young people hold negative attitudes towards the physical sciences and technology as school subjects.

Operationalising the hypotheses

Testing hypothesis one required an investigation of the students' perceptions of engineering and their attitudes towards it. As part of the operationalisation process, aspects of the negative image of engineering were identified from the literature discussed above and several sub-hypotheses were formed, as follows:

1a) Engineering is viewed as a masculine occupation

1b) Engineering is seen as boring

1c) Engineering is a profession with 'low visibility' amongst young people

1d) Engineering is considered a low status career

1e) Engineering is considered female-unfriendly

Indicators of the 'masculinity' of engineering embedded in the literature and relating to a particular version of masculinity included perceptions of it as male-dominated, manual work, needing physical strength, working with tools and objects and other characteristics typically associated with the stereotype of 'men's work'. Indicators of engineering's 'visibility' as a career were provided by the students' levels of knowledge of and awareness of engineering. Indicators of 'female-unfriendly' included hostile male attitudes towards women engineers, long working hours and a perception of engineering as incompatible with family life.

In the survey questionnaire, images of engineering were measured in three main ways. First, a word-association technique was used to elicit the students' subjective perceptions of engineers and engineering. Here respondents were asked to write down the first word brought to mind when hearing the word 'engineer'. Second, respondents were provided with a list of thirteen attributes, such as 'mathematical knowledge', and 'physical strength' and asked to rank the five they considered most important for an engineer. The third measure of images of engineering as a career was provided by a number of attitude statements with which respondents were asked to agree or disagree. These statements were designed to be both positive and negative and captured various aspects of engineering's image, derived from the literature. Negative statements included: 'Engineering seems boring compared to other jobs' and 'A woman going into engineering would have to cope with hostile remarks from the men'.

Testing hypothesis two required an investigation of students' attitudes and choices towards science and technology subjects at school. To assess the extent to which the students might hold negative attitudes towards science and technology as school subjects, indicators of 'negativity' and 'positivity' towards these subjects needed to be identified. This was not straightforward, as what may be negative for one student, could be positive for another. It was decided that one indicator of negative attitudes towards science and technology was not enjoying or not being interested in these subjects. This was hypothesised to be more likely for girls than for boys. This was measured in the survey by providing statements such as 'I enjoy science' and asking the students to agree or disagree along a Likert scale. A second indicator of negativity towards science and technology was not choosing these subjects for sixth form studies, although it was accepted that *not choosing* science does not necessarily indicate negativity towards it. Science and technology choices were measured both in the focus groups and the survey by asking students' to indicate which subjects they were studying in the sixth form. A third indicator of negativity towards science and technology was finding these subjects difficult. This last one was particularly ambiguous, as studies have shown that finding a subject difficult may lead to a negative attitude for girls, but a positive one for boys, who often have greater confidence in their abilities and may be more likely to accept 'a challenge'. Lips (1992: 78), for example, found that the perception that scientific careers are demanding and difficult was *positively* related to the uptake of courses and career goals in science or mathematics, especially for men. Subject difficulty was measured in the focus groups by asking students which subjects they considered to be the most difficult, and in the survey by asking students to rate a number of subjects along a difficult-easy scale (see below).

For hypothesis 2, sub-hypotheses relating to the various negative attitudes were formed as follows:

2a) Science, technology and mathematics are perceived to be more appropriate subjects for males than for females (i.e. they are considered 'masculine')

2b) Physics and mathematics are considered academically difficult subjects

2c) Physics, technology and mathematics are perceived to be more about 'things' than about people

2d) Girls do not enjoy the physical sciences, technology and mathematics as much as boys

2e) Girls are less interested than boys in the physical sciences, technology and mathematics

Measuring gender-stereotyped beliefs

In order to test the hypotheses that both science and technology at school *and* engineering careers are considered masculine, the research looked for evidence that students' held gender-stereotyped beliefs in relation to these areas. For both the focus groups and the survey, indicators of gender-stereotyped beliefs were developed. The focus group method, by its nature, compromises breadth of data for depth, and therefore covered fewer areas than the survey. One measure of gender-stereotyped beliefs used in the focus group interviews was the students' views about *gender and ability* in different subjects (see also Francis, 2000). Here the students were asked if they find any subjects particularly difficult and whether they thought girls are more able at some subjects and boys others. A second measure used to assess gender-stereotyped beliefs was the students' views about *gender-*

appropriateness, both for school subjects and for occupations. The interview asked students whether they considered their own sex to be better suited to some jobs than the other sex and examined how amenable the students were to considering a job traditionally associated with the other sex. Finally, the students' views of women's roles in engineering were assessed, by asking questions about women's suitability for engineering work. In the questionnaire, in order to assess students' perceptions of various subjects and in particular, the idea that particular subjects are considered 'masculine' or 'feminine', a technique was used that involved replicating and building on the work of Weinreich-Haste (1981 and 1986) and Archer and Freedman (1989). Here, the students were asked to rate a list of subjects on four dimensions, along a five-point scale, which included a neutral mid-point. The dimensions used were 'masculine-feminine', 'difficult-easy', 'science-art' and 'things-people'.

In addition to the areas already described, the investigation as a whole also sought information on the students' own choices in relation to careers, and the features they considered most desirable in a job ('work values'). The students' level of knowledge in relation to engineering was explored and, given that role models have been found to predict choices in engineering, students were also asked whether they had any personal connections with engineers as relatives or friends.

Choice of study population

Previous research has shown that the subject choices of students in single sex schools differ from those in co-educational environments (Ormerod, 1981; Colley, Comber and Hargreaves, 1994; Colley, 1998, Whitehead, 1996). There is evidence, for example, to suggest that girls studying in single sex schools are more likely to choose the physical sciences than those in mixed sex schools. For most young people, however, subject and career choices are made within an educational environment in which the opposite sex is present. For this reason, co-educational schools were the focus of interest in this study. In an attempt to achieve homogeneity within the study population, single sex schools, private schools and further education colleges were excluded in order to concentrate on students in the sixth forms of co-educational schools in the state sector. The study population was defined as curriculum Year 12 students (16 and 17 year olds) in LEA-maintained co-educational comprehensive schools in Plymouth and Bristol. Bristol was chosen because it has an arguably more obvious engineering presence than Plymouth and for this reason was hoped that some comparisons might be drawn between students' responses in the two cities. Financial and time constraints had to be considered and Bristol offered the advantage of being within relatively easy travelling distance for visits. LEA-maintained co-educational comprehensive schools with sixth forms were chosen as they represent the learning environment of a large proportion of young people in the UK and so offered some scope for generalisations to be made.

Method 1: The focus group interviews

Defining focus groups

According to Morgan (1998: 29), there are three basic defining features that all focus groups have in common. These are first, that they are a research method for collecting qualitative data, second, that they are focused efforts at data gathering and third, that they generate data through group discussion. A distinctive feature of focus groups is the use of group interaction and discussions to generate data (Morgan, 1998; Kitzinger and Barbour, 1999). This made the method particularly appropriate for ascertaining the views of secondary school students, who tend to form many of these views in the context of interaction with others in their peer group. By imitating similar contexts in which young people's views are formed, the focus group method can be more 'naturalistic' than some other methods, especially in cases like this, where pre-existing friendship groups are involved (see Kitzinger, 1994). However, both Kitzinger (1994) and Green and Hart

(1999) note that focus group interviews are still 'artificial situations' in the sense that they have been set up for a specific purpose. Green and Hart (1999:26) therefore conclude that the naturalism of the method may not be so much in the actual data that is collected, as in the insights that can be obtained into the *process* by which beliefs are formed within peer groups. This was of central importance in this study, which sought further insights into the process, or 'mechanism', by which gendered beliefs and choices about educational options and careers are perpetuated within the context of school.

Aims of the focus groups

One aim of the focus groups was to explore the topic areas qualitatively in order to generate research questions, hypotheses and questionnaire items for the self-completion questionnaire that would be used in the second stage of the data collection process. A second purpose of the focus groups relates to the criticism that quantitative methods typically 'strip data from their context' (Punch, 1998: 242) and the limited capacity of structured methods, such as self-completion questionnaires, to provide access to respondents' meanings. In contrast, the focus groups were able to tap into the 'actor's definition of the problem' (Punch, 1998: 243) and the transcripts were therefore a useful resource to refer back to in order to make sense of the survey responses and draw comparisons between the findings produced by the two different methods. The interviews set out to explore: the students' subjective reasoning behind their subject choices for post-16 education, the extent to which the students were aware of and influenced by gender stereotyping in the spheres of school and work, and the dominant understandings and images of engineering held by the students. It was also hoped to identify any factors which might attract the students to engineering, or repel them from it.

Advantages of the focus group method

The focus group method was chosen as it offered a number of practical and methodological advantages over individual interviews. First, it allowed data to be collected from a substantial number of participants with a minimum of time and cost. Second, it made access to participants within the school setting easier to negotiate for two main reasons. The first reason was that interviewing students in a group setting (rather than individually) was seen as less threatening and therefore more acceptable to their teachers. The second reason was that group interviews, being less time-consuming than individual interviews, could be more easily accommodated within the schools' timetabling constraints. Third, the method encourages talk, allowing the participants to react to and build on the views of other group members. A further strength of the method was that it allowed exploration of the topics in a relatively unstructured way, which enabled participants to discuss issues *in their own language* and raise topics which were pertinent to them.

The fact that the participants' own language and understandings of the topics could be captured in focus group transcripts meant that, where possible, these understandings could be incorporated into the questionnaire design for follow-up. As Oppenheim (1992) puts it:

> The tapes can be an invaluable source of useful question workings and attitude statements. Research workers tend to become too intellectual, and to develop the language of specialists; it is generally much better if attitude questions and statements can be put in the respondents' own, every-day language. Therefore the tapes should be combed for expressions and sayings that could be used as attitude items in a questionnaire – or in a subsequent depth interview (Oppenheim, 1992: 76).

As mentioned earlier in the Chapter, not only did the focus group research help to inform the design of the survey that followed, but also, the data served as a useful resource to refer to after analysing the questionnaires, in order to help interpret some of the relationships between variables (see Punch, 1998: 247).

Procedure

An interview guide was designed containing seventeen questions on the topics of subject choice, employment/careers and engineering (a copy of the interview guide can be found at Appendix I). The questions were pre-tested in an individual interview with a Year 12 student from a representative school outside the study population and found to be satisfactory. Although an individual interview was not representative of the focus group situation, pre-testing in this way nonetheless allowed some insights into how the participants were likely to interpret and respond to the questions and could gauge whether the questions would promote discussion (Stewart and Shamdasani, 1990: 66). Furthermore, as Stewart and Shamdasani (1990) point out, it is difficult to pre-test focus groups fully, as the interview guide is only one component of the method (the participants are another) and the unique dynamics of the groups in question will make a difference.

Eight single-sex focus groups were conducted with Year 12 students (16-17 year olds) during May and June 1999. The students came from four co-educational comprehensive schools, two in Plymouth and two in Bristol. One group of females and one group of males were interviewed in each of the schools. All four schools were maintained by their local education authority (LEA) and admitted pupils from the age of eleven to eighteen. Group size ranged from five to nine participants, who, between them, were studying a wide range of A level, AS level and GNVQ subjects (the composition of the focus groups is appended to this report). The group discussions took place within the schools, lasted between 40 and 60 minutes and were tape-recorded to facilitate analysis.

Sampling technique

Students in secondary schools are a difficult population to access directly, therefore access to individual students needed to be negotiated via teachers as gatekeepers. For this reason, the schools, rather than students, were the primary sampling units. Statistical representativeness was not the aim of the focus groups, which aimed for depth and insight rather than generalisability (see Morgan, 1998). Therefore the sample of participating schools was chosen on a purposive basis, as opposed to using a probability technique. It was ensured, however, that the participating schools conformed to the eligibility criteria of the defined study population (see above). A sampling frame (see later section on the survey) was used to select two schools from each of the two geographical locations. The sampled schools were approached initially by letter to the headteacher, inviting the school to participate, providing background details of the study and asking for written consent to contact key nominated staff who could identify student participants who met certain criteria (see below). All of the headteachers approached gave their written consent and nominated a member of their sixth form staff.

Recruitment of participants

Each of the nominated members of staff were then contacted by telephone to arrange an interview date and were sent written confirmation of the arrangements and the requirements for the selection of participants. They were also provided with background information about the research and a copy of the interview schedule to be used. The basic requirements were that the students should be studying a combination of mathematics and science subjects, that there should be approximately 5 to 9 students in each group and that girls and boys should be interviewed in single-sex groups. Before data collection commenced, the decision had been taken to interview the sexes in separate groups, for a number of reasons. First it was anticipated that for both girls and boys, the presence of the other sex would inhibit responses to questions that directly addressed issues of gender and sex-roles. Second, there was a concern that asking provocative questions about perceptions of sex roles in a mixed group may result in embarrassment or even antagonism between girls and boys. Third, there was a possibility that girls may not speak up in mixed groups and that boys might dominate, or if there was an imbalance in the sex ratio of groups, that one sex would dominate the discussion over the other. It was serendipitous that, due to an error in participant recruitment, an unforeseen opportunity was provided by one school to pre-test the interview guide with a mixed sex group of Year 12 students. This confirmed the hunch that in such a setting a 'sex war' did develop in the form of an argument between the boys and the girls over one of the issues. There was also a gender imbalance in this group with five male respondents and only two females. For much of the interview, the girls remained quiet and the boys did indeed dominate the discussion.

Particular criteria had been decided upon in advance for the selection of participants for the focus groups. These criteria were designed to select groups of young people who broadly had the potential to pursue the physical sciences or engineering at undergraduate level. In practice, this meant choosing students who were studying mathematics at A-level in combination with a science subject, physics where possible. Teachers were responsible for selecting students and these requirements were discussed with them by telephone and confirmed in writing ahead of the interview dates. However, sixth form teachers are very busy people faced by many organisational constraints in the day-to-day life of the school. This meant that in practice, the teachers did not have the luxury of collaborating in the 'perfect' research project and selecting the 'ideal' participants. Instead, the teachers selected participants using a variety of more pragmatic methods, which sometimes met their own priorities and agendas. Examples of these recruitment methods included: choosing students who had a free study period on a particular day, students who had expressed a particular interest in taking part in the research, students interested in engineering, students who were studying sociology and might like to see what a 'sociological' interview was like and students who 'owed favours' to the teacher for whatever reason! Consequently, the interview participants selected formed rather more heterogeneous groups in terms of the subjects they were studying than had been originally intended. However this turned out to be advantageous as it allowed valuable insights into the attitudes and perspectives of 'non-science' students. On the basis of these findings, it was decided that it would be illuminating to be able to compare the attitudes of 'science' and 'non-science' students towards the topics. Therefore the criteria for the survey sample were broadened to encompass the full range of subject options, as opposed to merely sampling students studying science and mathematics.

Analysis of the focus group data

The group interviews were tape-recorded and transcribed in full. The interview transcripts were then analysed using an 'ethnographic' approach which, according to Morgan (1988: 64) draws on 'more direct quotation of the group discussions', as opposed to what he terms 'content analysis', which, he claims 'typically produces numerical descriptions of the data'. The analysis of the transcripts followed several stages, involving examining the data at more than one level. Since the interviews had been semi-structured in style, using an interview guide (Appendix I), initially the analysis was steered by this, which entailed identifying the sections of each transcript that were relevant to the research questions. This helped to facilitate comparison of the groups on the various questions. Next, a 'cut and paste' analysis technique (Stewart and Shamdasani, 1990) was employed, to code and sort themes and topics that arose in relation to the questions. A further analysis strategy was to search for any obvious sex differences in the experiences, perceptions and attitudes of participants, although the scope for this was obviously limited, due to the small number of groups involved and the heterogeneity of the groups. While some analytic categories were fairly explicit at the outset, being closely linked to the interview guide, other, more implicit, categories were developed during the analysis. The most abstract level of analysis was concerned with uncovering the 'hidden' meanings around gender that the students were drawing upon and creating in their peer groups. This was achieved by drawing on a feminist post-structuralist framework to find out whether the participants were drawing on identifiable gender 'discourses' or 'narratives' in their conversations and is similar to the approach used by Francis (2000), discussed earlier in this chapter.

Method 2: The survey

Aims of the survey

Marsh (1982) has identified two primary uses of surveys: one that they are useful for demonstrating statistical trends, and two, that they can be used for causal analysis. Both of these were aims for the research, which aimed to describe the characteristics of a large sample of students in terms of their behaviour, choices and attitudes towards science and technology as school subjects and engineering as a career. The research was also concerned to investigate the ways in which gender interacts with other variables, to produce unequal outcomes for females in engineering. Therefore a research design was required that would allow comparison between female and male students (and other sub-groups) on a number of attitudinal variables and allow the search for relationships between variables. These considerations led to the choice of a 'cross-sectional' survey design (de Vaus, 1991; Robson, 1993; Bryman, 2001) for the quantitative aspect of the investigation. According to Bryman (2001), a cross-sectional design is characterised by several features. Primarily it involves:

> the collection of data on more than one case (usually quite a lot more than one), at a single point in time, in order to collect a body of quantitative or quantifiable data in connection with two or more variables (usually many more than two), which are then examined to detect patterns of association (Bryman, 2001: 41).

This latter emphasis on measuring variables and assessing the relationships between them further characterised the design as a 'correlational' survey (Stern and Kalof, 1996: 31; Punch, 1998: 78).

The questionnaire

As mentioned earlier, some of the data generated by the focus groups was used to develop items for a self-completion questionnaire with which to carry out a large survey of the following year's cohort of Year 12 students in co-educational comprehensive schools in Plymouth and Bristol. The survey was designed to measure the behaviour, intentions, awareness, knowledge and attitudes of the students in relation to three interrelated topics: 1) subjects of study, 2) careers and employment 3) engineering as a career. In brief, the survey collected information on the subjects the students had chosen for sixth form study; the main influences on their subject choices; their perceptions of subjects; their career aspirations; the factors they considered most important in a job or career; their intentions towards a career in engineering, and their perceptions of engineers and engineering. The questionnaire (see Appendix IV) was designed as a self-completion instrument, with the majority of questions presented in a closed-ended format, using tick boxes. A variety of question styles was used, including answer categories, attitude statements and ranking. A few open questions were also included where appropriate.

Questionnaire pilot

The questionnaire was piloted with a group of thirty-three year 12 students in a co-educational comprehensive school in Cornwall which was typical of, but outside the study population. At the end of the session, a small selection of these students were asked for their views about how easy or difficult the questionnaire was to understand and complete. Some amendments were made to the question wording in the light of helpful feedback from a number of these students. The piloting process allowed for two different ranking formats to be tested on a particular question in order that the easiest one could be identified and used on the final questionnaire.

Sampling technique

Since students in schools are difficult to access directly, achieving a probability sample would require a high level of co-operation and commitment from staff. In the face of the difficulties, time and expense that would be involved, a non-probability sampling technique was chosen for the survey, which (as with the focus groups) used schools, not students as the primary sampling units. Despite the inability to randomly select students, however, the sample was designed to be as representative as was feasible. The sampling strategy attempted to emulate the two-stage cluster sampling technique (as discussed in Arber, 1993; Sarantakos, 1998; and Bryman, 2001). The sampling frame for the schools was the 'School and College Performance Tables 1998', published in the *Times Educational Supplement*, 4th December 1998, which listed all schools in the catchment of interest by a number of criteria. From this list, it was possible to identify that twenty-two schools were eligible (11 in Plymouth and 11 in Bristol). Although the study focused on Year 12 students, disaggregated data for Years 12 and 13 was unavailable, therefore the total number of students in both these cohorts in the twenty-two eligible schools was added to give a figure of 2,825. It was estimated that approximately half of these would be in Year 12. The estimated number of Year 12 students in the eligible schools was therefore 1,411. Bristol has a far smaller number of students studying for post-16 qualifications in secondary schools, than does Plymouth. This is because many of the schools in Bristol have already, or are currently in the process of closing or amalgamating their school sixth forms, in favour of the larger FE colleges. Therefore 1,060 of the estimated Year 12 population were attending the schools in Plymouth and 351 the schools in Bristol.

It was decided that attempting complete enumeration of all the Year 12 students in all of the eligible schools was the best strategy. It was felt this would potentially introduce less bias than attempting to draw a sample of either a) all Year 12s from *some* of the schools, or b) some Year 12s from *all* of the schools. In the light of this decision, all twenty-two of the eligible schools were contacted and invited to participate. One school in each of the two cities refused to participate, due to time constraints and one further school in Bristol had ceased to be eligible, having recently closed its sixth form. This gave an 86 per cent response rate overall in terms of the participation of eligible schools.

Access to respondents

Access to the respondents was gained initially through heads of sixth forms/post-16 education, who were contacted by letter, briefly describing the study and asking if their year 12 students could participate by completing questionnaires. These letters were followed up by telephone calls to heads of sixth forms to ascertain the possibility of student participation in the study. Once teaching personnel had agreed to let their students participate, arrangements were made by telephone to deliver the required number of questionnaires to the school/college, either in person or by post. These arrangements were then confirmed in writing. Teaching personnel were requested, where possible, to distribute questionnaires to *all* of their year 12 students. Most teachers complied with this request, however some were unwilling to receive sufficient questionnaires for every student in their cohort, as they felt that some students would be unwilling and/or unable to participate. A few teachers set limits on the numbers of questionnaires they were prepared to receive, because of the extra work it would involve for them or their colleagues in administering and collecting it.

In total, 1427 questionnaires were either sent by post or taken in person to the schools. This number was slightly larger than the original estimate derived from the sampling frame as described above (1,411). This was because the number of questionnaires actually sent out was finally determined by sixth form staff in each school, who estimated the number of questionnaires required for their whole Year 12 group. 1030 of the questionnaires went to schools in Plymouth and 397 to schools in Bristol.

Administering the questionnaire

It was originally intended that all questionnaires would be personally administered, which would entail delivering, handing out, supervising completion of and collecting completed questionnaires from respondents. In the event, organisational and time-tabling constraints in schools prohibited this and teaching personnel preferred to administer the questionnaires themselves at a time convenient to them. Teachers therefore took responsibility for handing out and collecting completed questionnaires from students. In the case of all the Plymouth schools, the questionnaires were delivered and later collected in person, whereas all of the Bristol questionnaires were sent and returned by post.

Measures taken to minimise non-response

Several measures were taken in order to minimise non-response. Some strategies were built into the questionnaire design and other strategies employed after the data collection process. One strategy was to design the questionnaire to be as simple, easy to understand and quick to complete as possible. This objective was facilitated by pre-testing the questionnaire with a similar group of respondents, whose feedback was sought on question format and ease of completion. In the final version of the questionnaire, the majority of answers merely required a tick-box response, which made it quicker to complete. A further strategy was to offer a small inducement in the form of entry into a raffle for all completed questionnaires, to win one of three record tokens. The front sheet of the questionnaire took the form of an introductory letter, which described the project and provided clear instructions about how to enter the raffle. A third strategy was to provide postage paid envelopes to sixth-form staff for the return of completed questionnaires. Finally, follow-up telephone calls were made at regular intervals to remind relevant staff to return completed questionnaires.

Response rate

Questionnaires were distributed to Year 12 students in ten schools in Plymouth and nine in Bristol. In total, 610 completed questionnaires were returned, of which 4 were spoiled/unusable, therefore N = 606, representing a 43% response rate overall. This was a fair response rate, given that direct contact with the respondents was not possible and the teachers were the gatekeepers in terms of both administering and returning the questionnaires. All participating schools in Plymouth returned *some* completed questionnaires, however three of the Bristol schools did not return any.

Due to the smaller number of schools with sixth forms in Bristol, the proportion of eligible schools was much greater in the Plymouth area than in the Bristol area. In total, 140 completed and usable questionnaires were returned from Bristol schools, and 466 from Plymouth. Overall, the response rate for the Plymouth schools was higher than that of the Bristol schools (46% and 35% respectively) and the final sample comprises 77 per cent of students from Plymouth schools and 23 per cent from Bristol. There were no significant differences between the proportions of the sexes in the schools from each of the two cities. Item response rates remained consistently high throughout the questionnaire, despite expectations that the length of the questionnaire may result in response fatigue. The response rate for individual items never fell below 94%.

Non-response

Perhaps unsurprisingly, there was a higher response rate overall from Plymouth than from Bristol. This might be explained partly in terms of geographical proximity, in that Plymouth schools have more established links with the University of Plymouth than do Bristol schools. Therefore the Plymouth schools were likely to have more invested interest in the study and so were more likely to co-operate. Due to proximity, lines of communication were also easier to maintain with schools in the Plymouth area. Whereas it was easily possible to visit schools in Plymouth to collect questionnaires in person, time and cost constraints prohibited visits to Bristol to collect questionnaires, relying entirely on postal returns.

Some issues of measurement and analysis

Socio-economic status

Collecting data on students' social class is problematic as it is their parents/guardians, and not the students themselves who are likely to determine their socio-economic status. In the survey, two measures were used as indicators of the socio-economic status of respondents[1]. The first of these was derived from parental occupational status, having collected data on both of the respondents' parents (where applicable). However, one of the limitations of producing an occupational score in this manner is that it only applies to those respondents who gave data for two parents/guardians. It therefore excludes all those respondents living in households where one parent is absent (as well as those with missing data). In this sample, this method could only produce frequencies for 53.5% of the respondents. An alternative strategy was adopted whereby the occupational status measure was derived only from *one* of the respondent's parents/guardians. Where data was available for two parents, the parent with the highest level occupation was chosen. This measure was more inclusive

[1] A second indicator of respondents' social class was derived from parental levels of education. The measure was created using information collected on the level of education received by respondents' parents/guardians and divided into four groups, from leaving school at 15/16, to receiving a degree level education. A score from 1 to 4 was allocated to each of these levels of education. Each respondent was allocated one of these scores, derived from whichever one of their parents/guardians (where two were present) had the highest level of education. The distribution of respondents in these categories is shown in the following table:

Level of respondents' parents' education (derived from the parent with the highest level of education)

Level of education	Frequency	%
Left school at 15/16	295	56.6
Left school after A-levels	75	14.4
Went to college after A-levels	42	8.1
Went to polytechnic or university	109	20.9
Totals	**521**	**100.0**

As a check on the validity of the measures of students' social class, the parents' occupational status variable and the parents' educational level variable were correlated using Spearman's correlations. A weak positive relationship was found between the occupational and educational levels of the students' parents (Spearman's = 0.371, p = <0.01), providing some support for the validity of these measures.

of single-parent households and produced frequencies for 85% of the respondents. The parents/guardians' occupations were classified using the new SEC social classifications (Rose and O'Reilly, 1998). This process was not unproblematic, as much of the information given by the students about their parents' occupations was ambiguous, precluding more than a simple division between categories of occupation. One of the advantages of the SEC is that the full version can be collapsed into a three-class model, which was used in this study, where the categories of interest are Class I: Managerial, Class II: Intermediate and Class III: Working (see Appendix VI for the full version of the SEC and derivation of the three class version). The distributions of respondents in each of the three class groups are shown in Table 6 below:

Table 6: Parents' occupational status

	FREQUENCY	%
Class III (working)	164	33.1
Class II (intermediate)	72	14.5
Class I (managerial and professional)	260	52.4
Totals	**496**	**100.0**

The table shows that in the sample as a whole, respondents were found to be over-represented in Class I and Class III (52.4% and 33.1% respectively), whereas only 14.5% of respondents are allocated to Class II.

The over-representation of students in Class 1 may be due to a number of reasons. First, the top heaviness of Class I may be a function of the 'crudeness' of the SEC three-class version, the broadness and ambiguity of the category and the difficulty of categorising the students' responses. A second possible reason for the over-representation of students in Class 1 is that the sample comprises students who have stayed on at school beyond compulsory education. Given the widely established relationship between education and social class, it would be expected that those young people staying on beyond compulsory education may be more likely to have parents in higher level occupations than those who leave school at sixteen. A third possible reason for the top-heaviness of Class I parents may be due to what Oppenheim (1992: 139) has termed 'social prestige bias', where the students may have accorded their parents' occupations a higher status than is actually the case.

Some differences between the socio-economic profiles of respondents in Plymouth and Bristol schools were found. While broadly similar proportions of students from Plymouth and Bristol were found in Class 2 (Intermediate), a much larger proportion of Plymouth students had a parent in Class 1 (Professional and Managerial) than did Bristol students (56.4% and 37.7% respectively). Conversely, almost a half of the Bristol students (49.1%) had a parent in Class 3 (Working), compared with only just over one quarter of Plymouth students (28.7%). These differences were found to be significant (Chi-square statistic = 16.131, df = 2, p = 0.000), indicating that the schools in each of the two areas differed in terms of the students' social backgrounds. Without detailed local knowledge of the Bristol area, it is not possible to explain why there was an over-representation of students in the lowest social class group. Plymouth, however, is an area that is better-known to the researcher and a further check on the validity of this measure was made by comparing different schools in Plymouth in terms of the class profiles of students in each. This exercise revealed that those schools found to contain the highest proportions of Class I students were also the schools in the most 'middle-class' areas of the city. There is an extensive body of literature discussing the way that middle-class parents use their social, cultural and financial capital to ensure the educational success of their children (see for example, Bourdieu, 1997; Coleman, 1997; Reay et. at. 2001; Ball, 2003). The proportions of Class I students in these schools may well be enlarged by the effects of parental choice, whereby middle class parents are willing to drive their offspring across the City to 'good' schools as opposed to sending them to poorer performing schools in their own neighbourhoods. Ball (2003) touches on this issue in his argument that for middle-class parents choosing within the state-sector, 'being committed to comprehensive education does not mean that any comprehensive will do' (Ball, 2003: 121), in fact 'certain schools are revealed as being beyond serious consideration' (ibid. 2003: 104).

Ethnicity

Ethnicity was measured by presenting respondents with a list of ethnic categories from which they were asked to select the one that they felt best described them. The categories presented were designed to reflect the existence of known ethnic groups in each of the two locations and an 'other' option was included in order that the respondents could self-identify on any categories not already listed. The majority of students in both cities identified as 'English' on the ethnicity question (92 per cent of Plymouth students and 89 per cent of Bristol students).

Analysis of questionnaire data

The questionnaire data were analysed using the SPSS package. Univariate and bivariate techniques used included frequency tables, cross-tabulations using Chi-square, t-tests and Spearman's correlations. Sub-groups of respondents were compared using elaboration techniques. It had not been the purpose of the quantitative element to subject it to more than univariate or bivariate analysis and the research had not been designed with this in mind. However, it emerged that elements of the data could be subjected to multivariate analysis and this would be a possible next step following completion of the thesis.

Ethical issues

This final section of the Chapter reflects on some of the ethical issues relating to the study. The investigation conformed to the guidelines for ethical practice issued by the Faculty of Human Sciences and those of the British Sociological Association. Ethical clearance was sought from and granted by the Human Sciences Faculty Ethics Committee before data collection commenced.

Informed consent was one of the key ethical principles that needed to be addressed in the focus group method. This was obtained in the first instance from the head-teachers of each school *in loco parentis*. In advance of the interview date, sixth-form teachers were sent a list outlining the planned interview content (see Appendix X). Nearer to the interview date, the teachers were contacted by telephone to confirm that they were happy about the interview procedure and the planned interview content. Informed consent was obtained from participants before the interview, where time was set aside to brief the students about the study, its purposes and aims, the possible uses of the findings, the planned interview content and the fact that the interview would be audio-taped to facilitate later analysis. At this stage, the students were also made aware of their rights, including the right to withdraw from the interview at any stage, or refuse to answer particular questions without any disadvantage to themselves, or to their school. They were also assured that the taped data would be destroyed upon completion of the project, and that their anonymity would be protected and no comments would be attributable to them as individuals.

For the survey, a different procedure was necessary. The self-completion questionnaire was largely administered by sixth-form staff, so it was not possible to meet respondents face-to-face to verbally brief them about the research and make them aware of their rights. Therefore the principle of informed consent was addressed by providing the potential respondents with written information about the study, which they could use as a basis to decide whether or not to complete a questionnaire. This was achieved by using the front sheet of the questionnaire for this purpose. The front sheet outlined the purpose of the research and gave an indication of the content and the use to which the data would be put. Respondents were also given assurances of anonymity by informing them that their name was not required. They were also assured that all the information they provided would be treated as confidential.

Despite best efforts to meet the principle of informed consent, however, the fact that in this study both the interviewees and the questionnaire respondents were recruited by teachers meant that they did not necessarily constitute fully consenting participants. For example, a discussion with one teacher indicated that some students had been recruited to an interview group because they 'owe me a favour'. This was indicative to an extent of the power relationships that exist between pupils and teachers in school. Some of the students actually said that they had had little choice about participating and indicated that they had felt coerced into doing so by their teachers. This was addressed by apologising to participants, thanking them for participating, reminding them of their rights to withdraw, reassuring them that their contributions to the study were extremely valuable and setting aside time at the end of the interview for debriefing. Happily, despite the less than perfect recruitment procedure, the overwhelming majority of interviewees appeared to enjoy the experience of taking part.

A further conflict arose between the participants' right to withdraw and the role of interviewer in the context of focus groups. According to Flick (1998) the interviewer must attempt to:

> prevent single participants, or partial groups from dominating the interview and thus the whole group with their contributions. Furthermore, the interviewer should encourage reserved members to become involved in the interview and give their views and should try to obtain answers from the whole group in order to cover the topic as far as possible. Finally, he or she must balance his or her behaviour between (directively) steering the group and (non directively) moderating it (Flick, 1998: 115).

Being the perfect 'moderator' is easier in theory than in practice! In some interview groups, particular individuals dominated, while other participants hardly spoke. While it is the job of the interviewer to encourage everyone to participate, there is a fine line between this and 'bullying' someone who is reticent, or who may have informally decided to 'withdraw from the interview' in terms of not answering a particular question. This was dealt with in the main by gently encouraging the quieter participants, but not forcing them to speak, and regularly reminding the more dominant ones in a light-hearted manner that it would be beneficial to hear everyone's views.

Kitzinger (1994) and Morgan (1998) also raise the ethical issue of privacy in the context of focus groups. This is important, because in the focus group situation, participants not only share information with the researcher but also with the other participants. Morgan (1998:90) points out that 'over-disclosure' can be a particular threat to privacy when there are ongoing relationships between participants, as there were in this study of sixth-form students. Unlike participants recruited to other types of focus group settings, these students would be continuing to spend time together, often in close friendships, long after the interview was over. In cases like this, it is the researcher's responsibility therefore, to minimise such invasions of privacy, as they risk harming individuals' self-esteem and their relationships with others. Meeting this principle was not too difficult in this investigation, because questions were not of a sensitive nature. Nonetheless, it is always wise to anticipate a possible case of over-disclosure arising and have a strategy in mind for dealing with it. Very occasionally during one or two of the interviews, a few participants did show signs that they were about to discuss feelings or facts of a personal nature, which they may have later regretted. To address this, boundaries were set in advance so that if and when this happened, the participant was gently made aware that due to time constraints the next topic must be covered and in this way the discussion could be refocused.

Chapter summary and conclusion

This Chapter has discussed a range of philosophical, methodological, technical and ethical issues relating to the investigation. It has presented a rationale for using both qualitative and quantitative approaches within a realist framework and more specifically, shown how Pawson's CMO model is helpful as an approach to understanding and explaining the attitudes and choices of young people towards engineering. The ways in which this methodological approach is compatible with feminist approaches to knowledge were outlined, as were the many ways in which feminism had shaped the research design. The Chapter then went on to explain how the principal research hypotheses had been derived and operationalised, before discussing issues relating to the two methods used in the study: focus group interviews and a self-completion questionnaire survey. Some issues of measurement and analysis were explained before concluding the Chapter with a review of some ethical issues pertaining to the study as a whole and how these needed to be addressed within each specific research method. Chapter Three will present the findings from the focus group interviews with sixth formers, which formed the first phase of the data collection process.

CHAPTER THREE:

Exploratory discussions with sixth formers

Introduction

It was indicated in Chapter One that one of the most important determinants of young peoples' opportunities to pursue careers as graduate engineers is their decision to study mathematics and science beyond compulsory education. Entry to engineering at undergraduate level usually depends on an educational grounding in mathematics and physical science at advanced level, subjects that must be chosen by the student at the post-16 stage of education. The subject choice process is therefore a crucial 'filter' stage towards or away from an engineering career. Choosing to study science and maths is only part of the story however. Progression to an engineering career pathway must also be dependent on some awareness of engineering as a career option and sufficient interest in it to pursue it. Consequently, at least two questions are raised. First, which factors might discourage students from choosing maths and the physical sciences for advanced study? Second, what are the factors that are likely to discourage students from choosing to pursue engineering as a career? This chapter presents the findings of the focus group interviews undertaken with Year 12 students. The interviews covered issues relating to the students' subject choices, their career aspirations and their perceptions of engineering, with the aim of answering these and other questions. The chapter will begin by describing the nature and content of the focus group discussions, before going on to present the findings. Finally the chapter will end with a summary discussion of the findings and their implications for the next stage of the investigation.

The focus group interviews

The focus group interviews were designed to explore qualitatively the reasons why the students had chosen to study the subjects they had opted for in the sixth form. It also explored their attitudes towards school subjects, their career aspirations and their perceptions of engineering, with a view to finding out whether and to what extent choices and perceptions are shaped by notions of masculinity and femininity. A major strength of the focus group method is that it allows the researcher to access the ways in which participants think and talk about a particular issue (Stewart and Shamdasani, 1990), which would not be possible with more structured methods. Since the second stage of data collection was to involve a survey, it was intended that the interview data would be used to help develop items for a follow up self-completion questionnaire and wherever possible, to frame the questionnaire items in the respondents' own 'everyday language' (Oppenheim, 1992). At the outset of the investigation, the focus group method had been intended as an exploratory stage of data collection, primarily to inform the survey design. For this reason, detailed and complex analysis of the interviews did not take place before the survey was designed and carried out. Instead, the transcripts were initially analysed in order to look for regularities in responses to particular questions and to gain a clearer understanding of the ways in which participants understood the question. However, the focus groups were found to yield such rich data that they provided a valuable source to refer back to later. It was useful to analyse them a second time after the survey data had been collected, as they could help to make sense of the data as a whole and to interpret some of the relationships between variables. This Chapter contains the latter, more developed, version of the analysis of the focus group findings.

The interviews set out to explore the primary hypotheses set out in Chapter 2: that engineering as an occupation, and the academic disciplines relating closely to it (mathematics, physics, computing and technology), are perceived negatively. Since the main focus of the research is on issues of gender and the barriers to girls, the interviews paid particular attention to seeking evidence for or against the hypothesis that these disciplines are considered masculine. There is, however, more than one sense in which the term 'masculine' can be used. The sense in which 'masculine' was operationalised here related primarily to whether or not engineering disciplines are considered *more appropriate* for males than for females. With this in mind, the interview was designed to explore the extent to which the students' attitudes and choices towards science, technology and engineering, both as subjects and careers, might be affected by gender-stereotyped ideas about what might be 'appropriate' disciplines for females and males to study and work in.

Further aims were to find out what factors encouraged or discouraged students from choosing to study maths and science, and to what extent an interest and/or aptitude in maths or physical science could predict choice of an engineering career. Was it the case that a rejection of engineering is linked to a dislike of the sciences and technology, or is something particular to engineering that discourages young people from considering it as a career? The interview also aimed to find out what kinds of qualities students most sought from their future careers and establish to what extent these 'job values' matched with their perceptions of what engineering might offer.

The interview comprised three sections: the first section was concerned with subject choices, the second with career aspirations and the third with engineering as a career (see Appendix I for interview schedule). The subject choices section asked students questions relating to why they had chosen to study particular subjects. Students were then asked whether they considered some subjects to be more difficult than others and whether some subjects are better suited to one sex than the other. The section on career aspirations asked students which occupations they intended pursuing, what kinds of things they would most value in a job, and what they were looking for most from a career. Again, they were asked whether they thought some occupations to be more appropriate for one sex than the other. The last section on engineering asked students whether they were considering engineering as a career and whether they had relatives or friends in engineering. They were also asked what their perceptions of engineering work were, how much they felt they knew about engineering and the various routes into it and whether they considered some types of engineering to be more beneficial to society than others. Finally, they were asked questions relating to their perceptions of engineering work and of women's role within the profession. The findings will now be presented, organised around the three above-mentioned sections, beginning with subject choices.

Gender in subject choices

Reasons for subject choices

The students were asked which subjects they were studying in Year 12 and to give their reasons for choosing them. Lists of the subjects studied by participants in each of the separate groups and for all participants by gender are included at Appendices II and III. Consistent with Garratt's (1985) findings on subject choice, the reason most frequently mentioned by the focus group participants for their choice of subjects was enjoyment. Other reasons mentioned included having an interest in the subject, the career value of the subject, the fact that the student possessed an aptitude for the subject which had been demonstrated by their GCSE results, and advice they had received from teachers, all of which support Garratt's findings.

A small number of the participants were studying GNVQ subjects, which have since been replaced by AVCE (Advanced Vocational Certificate of Education). When asked why they had chosen these courses, a few of these students saw their programmes of study as linked to a definite career aim. Many more gave other reasons for taking a GNVQ course, amongst which were the desire to enhance their GCSE results, the belief that GNVQs are 'useful', and a preference for coursework assignments rather than end of year examinations, which were more typical of A-levels at the time of data collection.

Constraints upon subject choices

To establish the parameters within which subject choices were typically made, participants were asked if there had been subjects they would have liked to study but were prevented from doing so for some reason. Most of the A-level students felt there were some constraints upon their subject choices. The three most frequently mentioned reasons for this were that two of their desired subjects clashed on the timetable; a particular course was not being run because there had been too few pupils interested in the subject at the stage when option choices were being made; and the particular subject they wanted was not offered at their school. The schools concerned seemed to have made good efforts to provide their pupils with the opportunity to study desired subjects at another school or college. On the whole, however, this was not a popular option with participants, who did not want to spend their free study periods travelling elsewhere or have to begin an A-level with an unfamiliar group of people. These views are typified by the following responses:

> ... it means that you go right across town, it takes about an hour on a bad day and it was just ... It's silly .. distance to travel (female, group 2)
>
> It's a bit awkward getting to (*alternative school*) and that because you have to get there between lessons (male, group 3)
>
> I live five minutes away (*from current school*), I don't wanna go there (male, group 5)
>
> I didn't really wanna leave this school and go somewhere totally different, I think I'll learn more and do better here because I got people I know around me (male, group 5)

Students in one group complained that art and science A-level subjects had been allocated to separate 'subject blocks', which could not be combined. This meant, for example, that subject combinations such as physics and theatre studies were unavailable, serving to reinforce the science-art distinction.

> Participant A: I wouldn't mind doing theatre studies, because I thought I really enjoy drama
> LH: Yeah?

> Participant A: It was just that ... because the block system we have in this school, they have all the arty subjects you're able to do all together in general and all the ... like sciency subjects you're able to do all together, so that's the general blocks you want
> LH: So there's no need to separate them?
> Participant A: Yeah, I wanted to do like chemistry, maths, biology and theatre studies, but I couldn't do it, 'cause they were all clashing
> (male, group 5)

The role of school timetabling in reinforcing the distinction between 'sciences' and 'arts' should not be overstated here, however, as this was the complaint of only one or two students and would need further exploration to determine the practices of schools more generally.

One student had changed his mind about taking an A-level subject because he did not want to be the only person studying it, whilst two others had to drop or change to a different subject because they found their original choice too difficult at A level. One of the Bristol schools was in the process of phasing out their sixth form and, therefore, could not offer such a broad range of subjects as in previous years. For the GNVQ students, constraints mentioned were mainly related to the level of the award they were studying. Many of the students had been entered by their school for an Intermediate level award, whereas some of these students said they would have liked the opportunity to take the Advanced level. Other students complained that the choice of GNVQ subjects on offer was limited. Despite the various constraints on choice, however, most participants felt reasonably happy with the subjects they had ended up studying. No participant mentioned constraints on their subject choices that were related to their gender.

Perceptions of subject difficulty/easiness

It has been argued elsewhere that the perception that 'the sciences' (physics, chemistry and mathematics in particular) are 'difficult' is widespread (Lightbody and Durndell, 1998) and acts to discourage many students from continuing with these subjects beyond compulsory education. This is likely to have a greater effect on those students who are less confident in their abilities, particularly girls, who have consistently been found to underestimate their achievements in comparison with boys (Whyte, 1986; ASE, 1990; Trankina, 1993; Erwin and Maurutto, 1998; Quicke, 1998). To explore this issue in the present study, participants were asked whether they considered some subjects to be more difficult than others. The participants understood this question in a number of different ways and it raised a variety of issues for them. Responses to this were therefore wide-ranging, but can be grouped into several related themes:

Individual aptitude

Responses in this category drew on a 'discourse of individuality', as discussed by Francis (2000: 41). Here, academic subjects themselves are considered neutral, so whether or not a subject is difficult or not depends upon the abilities and aptitudes of the individual. This view was expressed by participants of both sexes and is represented by such responses as:

> Well, it depends what you're good at - I mean some people find some subjects easy and some find sort of other subjects hard (male, group 5)
>
> everyone's good at their own thing (female, group 2)
>
> It depends on the kind of person you are, doesn't it? (male, group 7)
>
> it's personal - it's preference really (female, group 2)
>
> Well, it's just the way you think (female, group 8)
>
> they're all hard if you're not, you know, good at them at the beginning and if you're not interested in them then it's even harder because it just doesn't ... you just don't wanna do it (female, group 2)

The GCSE/A level gap

Many of the students interpreted the question in terms of whether certain subjects were more difficult than others at their present stage of education, i.e. Year 12, than they had been earlier in their education. Many, therefore, drew comparisons between A-levels and the GCSEs they had studied in the previous year. Most responses in this category tended to relate subject difficulty to the academic 'gap' between GCSEs and A-levels, rather than drawing distinctions between A-level subjects themselves. This gap was described mainly in terms of the course content, workload, teaching style and learning style, which were felt by most participants to be very different to what they had been used to at GCSE and to make A-levels much more difficult. For example:

> I struggled when I first started A levels, 'cause I wasn't prepared for the jump from GCSE and it just came as such a shock, like you're getting Fs and Es, compared to As and Bs (*at GCSE*), it really did hit you (female, group 6)
>
> it's like (in GCSE) you get taught everything, you get given everything to you, but with A levels you have to go out and find it (female, group 8)
>
> "I think History - we didn't realise quite what a leap that was, so the content we were doing we were finding all right, it was a slightly different way of doing it because we weren't actually taught it, we had to go and make notes for ourselves and find out the information, but it wasn't like really really difficult, the workload was slightly more, but it wasn't really really hard was it? And then, we got into the exam and out of eight of us, only three of us passed" (female, group 8)

Other responses in this category expressed the view that there was a big gap between GCSE and A level in *particular* subjects. Chemistry, biology, languages and history were identified as subjects which are much more difficult at A level than at GCSE. There was considered to be more of a continuum from GCSE to A level with Mathematics and Physics by a few of the male respondents. Chemistry was the subject most often perceived to be difficult. This perception was shared by both sexes, who were studying the subject in roughly equal numbers:

> it's the same in our Chemistry, 'cause you learn quite basic stuff in GCSE and suddenly you have to learn all these different theories (female, group 8)
>
> Actually, we got to our lesson and he said "right, forget what you've been taught at GCSE, 'cause none of it's true" - we're like, "Oh!" (female, group 8)
>
> I find maths and physics...I find them quite easy, comparing them to chemistry, 'cause I do that as well - chemistry seems so much harder than those two. Chemistry you gotta know everything just to work out one little thing. You need to know so much before you can do anything. There's knowledge on rules and like structural names and stuff - you gotta know so much, there's a lot of learning and remembering and...it's a lotta work to do (male, group 3)
>
> Say for Chemistry, it's like the fundamental things of it is just so different from anythink' else that we've done before, which just makes it a whole lot harder (female, group 8)

The 'Science/Art' distinction

Participants also discussed subject difficulty in terms of a distinction, or opposition between 'science' and 'art'. That is, they assumed that individuals were adept at *either* science (which included mathematics and technology), *or* art (which for them also meant subjects like English, history, sociology and religious studies) but not both. Examples of the oppositions made between science and art are typified in the following statements:

> It depends how your mind works, whether your mind works scientifically, because I can't do science to save my life but... (female, group 8)
>
> Some people can grasp maths better than art, some people are good at art but can't understand maths (male, group 5)
>
> 'Cause some people are more practical, so they do like the sciences and things like that, while some people just prefer like, writing, and can structure essays and things (female, group 8)

Whilst both male and female participants made these science/art distinctions, the sexes tended to hold opposing views as to which of these is difficult or easy. Many of the girls believed subjects they perceived as needing 'the one right answer' to be more difficult:

> I think it's like, well, physics and chemistry - you've got like... answers - you've got so many formulas to learn, whereas English and things like that are more perceptional and it's more your own opinion (female, group 4)
>
> Well, biology's OK, 'cause there's no straight answers for it and you can sort of ... there can always be a few right answers, but chemistry is always got to have one answer and it's very, very hard (female, group 4)

Writing

Writing essay-type answers involving reasoning and critical evaluation emerged as a skill which many boys seemed to find difficult, or at least, claimed they 'don't like'. Boys from all the groups expressed the view that subjects they perceived to be 'fact based' or practical, such as maths, some sciences (although not chemistry) and art, are easier:

> Participant A: I mean if you do English, you gotta write loads of essays, whereas if you're doing something like maths, you just, you know, do the sums and ...
> LH: Do you think it would be harder then to write loads of essays?
> Participant A: It depends on the kind of person you are, doesn't it?
> Participant B: Yeah, I find it harder to write...to do English than maths, 'cause I find that with geography, when we've got to write extended answers...
> LH: Yeah?
> Participant B: Well, I can get all the facts down and all the statistics an' everythin' else
> LH: Yeah
> Participant B: But when it comes to actually explaining it I just can't - well I can, but...
> (males, group 7)

Participant A: Apart from the Literature, which you can generally read, you have to have a certain way of expressing your opinion and that isn't always easy for someone like me. I'm hopeless at expressing my opinion.
LH: You're doing well now! (*laughs*)
Participant A: On paper, on paper! I can talk for hours, *hours* - I just can't write it down on paper (*laughs*)
(male, group 5)

I'd say the essay writing's the hardest part, 'cause they expect a much higher level, yeah, they expect you to write more and support your content with proof (male, group 1)

I mean I don't like essay writing, I don't like writing long essays so I chose sciences 'cos they're usually short right or wrong answers (male, group 3)

Art's easy ...it's just lots of coursework ...and doing projects. There's not much writing involved , not at A level. At GNVQ there's quite a lot, but at A level there's not, you just have to do little paragraphs to go with the design work (male, group 3)

It was possible then, that boys' over-representation in particular subjects can be partly explained by the fact that they have more negative attitudes towards reading and writing than girls (Clark, 1998: 37) and therefore attempt to avoid subjects with a high language demand.

Subject status

The way in which subjects were valued differently and hierarchically emerged in discussion amongst one group of males where the topic of 'A List' and 'B List' subjects was raised. The students were asked to elaborate on what they meant by this and responded as follows:

Participant A: Well, A List subjects, they're sort of like just generally grouped - A list are like the more academic things like Maths, Physics, Economics, Chemistry, 'fings like that
Participant B: Humanit... um, it depends. All arty subjects would be B List and depending on ... say you were doing three subjects and two of them were B list and you wanted to do like, law or something, you wouldn't get in 'cause they take A list subjects I think - physics, chemistry, maths, technology, economics... if you went to a university and said well, I've got As across the board but two of them are B List subjects... they'll take the guy with the two As from A list subjects
LH: Where's all this come from?
Participant B: I dunno, we were just told this weren't we?
LH: Who told you?
Participant B: The school, sixth form we had social education lessons and that's where they told us, we first heard it there
(males, group 5)

It was clear from this discussion that to some extent teachers had had an influence on the students' perceptions of the value and status of subjects. The physical sciences and mathematics appeared to be more highly valued and considered more 'academic' than some of the other subjects. The perception that sciences are more difficult (and therefore higher status) than arts subjects had been further reinforced for some students by university prospectuses. These students were under the impression that some science degrees required a higher number of A-level points for course entry:

> (*mockingly*) Right, shall we go and get the university entry book right and let's see, let's see the points we need to go and do maths, physics, chemistry and let's see the points we need to do art! (male, group 5)

Finally, the view that one must be clever to do science subjects like mathematics, but not 'arts' subjects was expressed here, as it was elsewhere in the discussion. However, it was contested in this all male group by one of the participants who was studying the 'feminine' subjects of sociology, religious studies and history:

> Participant A: But the...like academic subjects, like, I wouldn't say English was as academic as something like maths because...
> Participant B: I think it's the other way round, personally. I think that arts subjects are much harder than like... science and physics
> Participant A: Yeah, but you don't have to be clever to do 'em
> (*laughter from group*) (males, group 5)

Relations with teachers and peers

A few of the students referred to factors within the learning environment to explain why a subject was harder or easier. These factors included the perceived quality of the teaching; the pupil-teacher relationship; the motivations and attitudes of classmates and the number of pupils taking the course. Representative comments include:

> English is easy because the teacher's good (male, group 1)

> ... and if you don't get on with the teachers it doesn't help (female, group 2)

> I think it's difficult if you got like a large number and you got like, you know, stupid idiots in the class that just ruin it for everybody else, you know? (female, group 2)

The gender hierarchy of subjects

As mentioned earlier, no participants related their subject choices, or constraints on these choices, to their gender, tending to see these as a matter of individual preference and aptitude. However, several dichotomies emerged during the participants' discussions of subject difficulty, which reveal that implicitly, many subjects do have gender attached to them. When considering whether subjects were difficult or easy, participants of both sexes tended to draw on a set of distinctions between subjects, construing them as either: science or art, factual or 'perceptional', reporting the facts or explaining, short answers or essay writing, high-status or low-status and academic or creative. Both sexes tended to share the view that students were generally not able in both science *and* art subjects, but in one or the other. Males and females did, however, tend to disagree about which subjects they find easiest. More girls than boys said they find subjects like English and others with the scope for creativity and interpretation easier than those subjects which require 'one right answer', like mathematics and chemistry. Boys tended to say they find the 'fact-based', practical subjects, like mathematics, science, technology and art easier than those involving extended answers or essay-writing, which relied more upon the ability to express oneself and provide explanations. A dislike of writing was widespread amongst the boys and found in all the male groups, which may help to explain their avoidance of and under-representation in language-based subjects. Both sexes, however, who were studying chemistry in roughly equal proportions, agreed that chemistry is one of the most difficult subjects. There was, however, a contradiction in this discourse of subject difficulty, since on the one hand, many of the boys agreed that maths and sciences were easiest for them (because of the low writing demand), they also constructed these subjects as the most academically difficult subjects, as did the girls.

Perceptions of subject difficulty appeared to relate directly to perceptions of subject status. Those subjects that males have traditionally preferred and studied tended also to be those that were the most highly valued amongst these male participants, who also believed that universities hold certain subjects in higher regard than others. The discussion that had emerged amongst one group of male participants' about 'A list' and 'B list' subjects illustrated this. Mathematics, physics, economics, chemistry and technology were identified by this group as the prestigious A list subjects, whilst all 'arty' subjects were consigned to the B list. The subjects on the A list were also considered to be the most 'academic' subjects and those for which you need to be 'clever' in order to study them.

These findings tended to confirm the arguments of Weinreich-Haste (1986), Walkerdine (1989), Thomas (1990) and discussed by Francis (2000): that there is a gender hierarchy attached to subjects. In the dichotomies constructed by the students, many of the subjects that have been traditionally associated with the males and masculinity are described by the terms in the left side of the dichotomy, whereas those that have been associated with females and femininity are described by the terms in the right side of the dichotomy. At the same time, many of the terms in the left side of the dichotomy (science, difficult, factual, 'A list', academic) were accorded a higher status than those on the right.

Perceptions of sexual difference in aptitude for particular subjects

To further explore students' awareness of the sex-stereotyping of subjects and gender differentiation in subject choice, participants were asked if they think their own sex is more able or 'better at' some subjects than the opposite sex. Responses to this question can be divided into two main categories, the first tending to deny sexual difference and the second emphasising it. Following Francis' (2000) work on pupils' perceptions of subject ability, the first 'discourse' in the present study might be classified 'no gender difference in ability' (Francis, 2000: 41). Within this response, participants of both sexes felt that a person's sex was irrelevant to their academic success or choice in particular subjects, or they were reluctant to make generalisations. Responses of this type tended to attribute subject achievements to individual personality, aptitude or preference.

> "Not particularly, depends on the person individually" (male, group 7)
>
> "there's only really genetics that make them a girl or a boy" (female, group 2)
>
> "I don't think it's anything to do with them being *better*, it's just what they *enjoy*" (female, group 8)

Comments of this type seemed to sit comfortably with an 'equal opportunities view' evident amongst the participants and reflect the 'discourse of equal opportunity' found in other studies (see Henwood, 1996 and 1998; Francis, 2000; Walker, 2001; Aveling, 2002).

A second, competing discourse can be classified as 'gender difference in ability and interests', where participants drew on understandings of sex difference with regard to ability and interests in academic subjects. Within this second discourse, a number of themes, or 'narratives' emerged, three of which are very similar to those found by Francis (2000), namely: 'the sexes are good at different things', 'female superiority' and 'boys problematic behaviour'. These discourses will be described in the following pages using the same terms that Francis uses in her work.

Of those participants who attempted to explain the sex differences they had observed, only one participant explicitly attributed them to biological differences between the sexes and this was to use the argument that girls outperform boys because they 'mature faster'. This is a popular argument, Walkerdine (1989), for example, draws attention to the fact that girls are frequently described as 'mature' by teachers. However, Walkerdine argues that this can be negative as well as positive for girls and can contain pejorative meaning in relation to assessments of the relative intellectual abilities of girls and boys. Her argument is that girls termed 'mature' are assumed to have already reached their intellectual maturity, whereas boys, whether they are high or low achievers, are referred to as 'late developers' (Walkerdine, 1989: 100). The assumption behind this view is that boys have the 'natural' ability to outperform girls, whether this is now or eventually. This perception is harmful when it can serve to marginalize girls' achievements and undermine their confidence in their abilities.

Other participants either did not attempt to explain the gender differences, or explained them with reference to structural and cultural factors. Observed sex differences in subject choice and achievement were interpreted in a variety of ways:

The sexes are good at different things (see also Francis, 2000)

A few participants pointed out that boys and girls tend to be good at *different* subjects. These beliefs tended to take a traditional form, in which boys were thought to be better at science and maths and girls at English and arts:

> Participant A: (girls are better) At creative things I think
> Participant B: Yeah, like English, things like that
> Participant A: Boys are better at things that've got a certain logic (*laughs*)
> Participant C: Not all the time
> Participant B: But then, you look at English, it's all girls, there's one boy in our English
> Participant D: In English language there's two boys and all the rest are girls
> Participant A: In physics it's all boys as well
> (female participants, group 4)

> Participant A: In our maths class there's only two girls
> LH: Out of how many?
> Participant A: Ten, twelve at least.
> Participant B: I think that it's better if you go to subjects like English and sociology it's basically all girls
> Participant C: More girls
> (male participants, group 7)

However, rarely were these observed differences *explicitly* attributed to innate differences between the sexes and they were often qualified by social and cultural explanations (see below).

Girls and boys have different interests

Some participants related the discussion of sex differences in aptitudes to sex differences in *interests* in and *preferences* for subjects and how these preferences might impact on subject choice. Girls' low participation in subjects such as physics and mathematics was explained by participants in three of the groups in terms of girls' 'lack of interest' in them, rather than any lack of ability:

> Physics. Boys seem to be more interested in, like physics, rather than girls (male, group 3)
>
> Participant A: Well if you look at our classes, specially our physics class, there's only one girl
> LH: How many boys are there?
> Participant A: Thirteen, fourteen
> LH: That's quite a difference
> Participant B: Yeah, but it doesn't mean that boys are *better*
> (males, group 7)
>
> Participant A: They (*girls*) could do maths or they couldn't - they *could*...
> LH: They could in theory?
> Participant A: Yeah, but they're not interested. I mean, quite a few people (*girls*) could have done maths if they'd wanted..
> (*other voices in agreement*) "Yeah!"
> LH: So you think they're not interested in that really?
> Participant A: Yeah, that's why they haven't chosen the subject, I mean, they got higher grades ...in GCSE the girls got higher grades than the boys, but the boys took the subject and the girls didn't, 'cause they've no interest
> (male, group 7)

Mac an Ghaill (1994) noted in his study that the argument that girls and boys have different preferences was one that was supported by male teachers to explain the low numbers of girls studying technology and business studies. He found that these teachers tended to construe the students' choices on the basis of 'natural' gender differences (Mac an Ghaill, 1994: 116). Many of the students in this study had noted that although girls had ability in maths and were capable of studying it at A-level, they had not chosen to pursue it beyond GCSE. In the absence of alternative structural explanations, it was easy to see how girls' preferences and choices might be understood by the participants as the outcome of 'natural' sex differences.

Female superiority (see also Francis, 2000)

In contrast to the view that girls and boys are good at different subjects, many more participants of both sexes thought that girls were better at *most* subjects than boys. Francis also found this view amongst the respondents in her study, and termed it the narrative of 'female superiority' (Francis, 2000: 42). She suggests that this response could be prompted by the male underachievement debate and, following girls' success at GCSE level, the 'new, emerging awareness of female achievement at secondary school level' (Francis, 2000: 43).

> LH: You think the girls were pretty much better at everything?
> Participant A: Specially things like English and maths, things like that, 'cause we had more of a concentration span than the boys did
> Participant B: I think probably girls are more in tune with their feelings and like their emotions than blokes are, I think they just like know what to say - blokes are like... "don't care"
> (females, group 6)
>
> Participant A: I think girls are generally cleverer than boys. Apart from our maths group (*mocking laughter from group*)
> Participant B: (*guffaws*) Yeah, but ...
> LH: How many girls are there?
> Participant B: Two
> Participant A: There's two
> LH: Out of how many doing maths?
> Participant B: About twenty or something
> Participant A: Fifteen
> LH: So you've got two out of about ...
> Participant B: Fifteen, sixteen
> Participant A: Yeah they are, they are really bad
> Participant B: (*laughing*) they are awful
> (males, group 5)

Despite being prepared to acknowledge that girls are 'good at everything', there was also evidence of 'male unease with female success', which supports the findings of Walker's study (Walker, 2001). It was of interest to note that in this latter interview group, the boys appeared to feel threatened by the 'female superiority' discourse and were keen to keep mathematics, a traditionally 'masculine' subject, for themselves.

There was evidence elsewhere in the discussions that, despite the 'discourse of equal opportunity', there was at the same time a competing discourse that acknowledged the entrenched stereotyping of particular subjects as 'masculine' or 'feminine'. This was particularly evident in discussions of technology. Some of the participants' responses expressed surprise that girls had proved their competence 'even in technology', revealing the taken for granted assumption that it is a subject in which boys are more able or more comfortable:

> That depends on what it is really - like...you would think DT (*design and technology*), boys would be better at it, but it's not in all cases, 'cause when I done...woodwork wise, when I done it, there was like some projects that *girls* done better than boys (male, group 1)
>
> *Even* like, technology - which I did, the girls were better at that as well (female, group 6)

In further relation to the technology-masculinity connection, one female participant pointed out that in her sixth form, music A-level was a subject studied by girls only, whereas music *technology* A-level was studied by boys only and that it might be the 'technology word' which attracts boys and puts girls off:

> Participant A: There are four boys...doing music technology, but no girls
> Participant B: I think it's the 'technology' word
> (females, group 8)

Boys problematic behaviour (see also Francis, 2000)

Closely related to the above view that girls are better than boys at everything was a widely held view about why boys don't achieve as highly as girls in terms of examination scores. In this narrative, sex differences in study *attitude*, that is, motivation for study, rather than intelligence or aptitude, were emphasised; boys' lesser success, particularly with reference to GCSE performance, is blamed on their problematic behaviour. Again, this was a narrative found by Francis (2000) which, as already mentioned, she relates to participants' awareness of girls' success at GCSE level. Participants in all groups were unanimous in the view that girls 'work harder' than boys do, particularly up to the end of their GCSE studies in compulsory schooling. Many also felt that once students reached post-compulsory education, there was little difference between the sexes in their motivation to study because the 'naughty boys' had left school:

At GCSE level I thought that (*girls are better at all subjects than boys*), but um now it's not so much, 'cause um, well there's a lot of people left (*school*) at the end of the GCSEs (female, group 6)

I think, well, especially at GCSE level, they (*girls*) work harder than boys (male participant, group 7)

'Cos at GCSE it was definitely girls worked twice as hard as we did (*to rest of group*) come on, we were lazy gits! (male, group 5)

It's pretty even between...like in the sixth form I would say that there's no difference between the level of boys and girls" (male, group 1)

Participant A: It wasn't necessarily that girls were *better*, but they were more keen to learn
Participant B: Yeah
Participant C: They paid more attention
Participant A: Now, in A levels, I mean you've got the boys who *want* to do it, not the ones who were forced to
(females, group 8)

Participant A: I think that girls, right this is only my opinion...I think that girls and boys are equally intelligent, but girls work harder - boys wanna be like "I'm hard"
Participant B: Their image
Participant A: That's it, yeah
(females, group 2)

Participant A: I think ... well, especially at GCSE level, they (girls) work harder than boys
LH: I've heard that before (*laughing*), some other people have said that. Yeah? You think they work harder?
Participant A: Yeah, so yeah, at the moment they (girls) would be better at English. I mean, they got a better grade, but whether they're *better* ...
Participant B: We *could* do it, we just don't try
LH: And why don't you try?
Participant B: I wouldn't do it, 'cause I don't like writing essays
Participant C: I don't like English
(males, group 7)

On the face of it, it may seem that there has been a positive shift in thinking about gender and ability in favour of girls and Francis optimistically suggests that the impact of the 'female superiority' discourse could grow if female achievement is maintained (Francis, 2000: 47). However, implicit in the narratives about boys problematic behaviour was the assumption that boys had the ability to achieve 'if they wanted to', whereas girls' success tended to be perceived as the result of hard work, rather than innate intelligence. This assumption is potentially negative for girls as it challenges the discourse of 'female superiority' and lends some support to the argument made by some commentators that underneath it all, boys are still perceived as innately more able than girls (Walkerdine, 1989; Weiner, Arnot and David, 1997; Quicke, 1998; Scaife, 1998).

Other boys in the groups were less comfortable with the 'boys problematic behaviour', or 'girls work harder' arguments and more inclined to attribute girls' success relative to boys to the belief that males have less time to spend on schoolwork than females:

> Participant A: Girls have got more free time as well
> LH: Have they? How?
> Participant A: I dunno really, 'cause lads always seem to be out, just in general really (*laughter from group*), so girls have a lot more time to study. Well I find that really to be honest (*laughs*).
> LH: So you think that girls might be putting in a bit more time than boys in general?
> Participant A: Well, especially in writing, in English and history and subjects like that, 'cause they've got loads of spare time to do it.
> (male, group 3)

Participants of both sexes attributed boys' lack of time and motivation for study on their involvement in sporting activities:

> I just think there's social groups and the boys like generally don't do well because they're interested in sport and all that lot, um ... and I think ... like the girls, they're career-orientated. I think if boys were more career-orientated they could do well at anything.
> (male, group 5)

Whatever the reasons employed to explain the lower performance of boys, the underlying assumption was that boys would achieve more highly if they were not restricted by circumstances. This discourse served to reinforce the view that boys are innately more clever than girls.

Boys' involvement in sport was a recurring theme. This was both taken for granted and considered detrimental to boys' academic success, presumably because time spent on these activities could otherwise be used for study. There was a sense in which participants of both sexes tended to assume that boys had little or no choice but to spend time involved in sport. Mac An Ghaill (1994) has drawn attention to the link between sport and masculinity in his work on the construction of masculinities within the context of secondary schooling. In this work, Mac An Ghaill (1994: 163) identifies the process by which sport, particularly football, is used to 'construct dominant forms of straight masculinity' and serves 'to devalue, marginalize and threaten femininities and subordinated masculinities'. Interestingly, this process was evident in one of the male interview groups in the present study, where shifting the discussion to football was used as a strategy by one participant to marginalize the views of two other participants and question their masculinity. This part of the discussion involved a disagreement between one participant who was studying traditionally 'masculine' subjects and two members of the group studying 'feminine' subjects over the relative academic status and difficulty of 'the sciences' and 'the arts'. Here, the participants were drawing comparisons between the skills involved in mathematics and sociology. The view of the participant studying maths was that sociology is an easy subject, because 'anybody can come up with their own opinion'. The two boys studying sociology disagreed and tried to explain that sociology is about being able to understand and interpret the ideas of others:

> Participant A: Yeah but anybody can come up with their opinion on an argument
> Participant B: Yeah, but it's not just the opinion of yourself, it's the opinion of everyone else
> Participant C: It has to incorporate all different kinds of thinking
> Participant A: (*aggressively*) Yeah?
> Participant B: I mean, you don't just sit there and write down your own opinion, you've gotta take into account everyone else's as well
> Participant C: Yeah, you have to analyse what other people have said, don't you?
> Participant A: OK, well take anything right … right, anything you can form an opinion on right … say like "do you like football" right? You can come up with an opinion right?
> Participant C: But if I come up with a completely irrelevant point, like "I quite like basketball" you know, or something about elephants …
> Participant A: (*aggressively*) Do you like football is a 'yes' or 'no' answer? It's not hard!
> Participant C: It's completely irrelevant. I mean … it has got relevance, but …
> Participant B: We're not studying about football
> Participant A: What?
> Participant B: We're not studying about football
> Participant A: (*aggressively*) No, you're studying opinions and whether I like football or not is an opinion.
> (males, group 5)

The participant studying mathematics became very aggressive in the face of opposition to his views from the other two participants. As a way of marginalizing these participants in front of the peer group, he attempted to force them to take a view on football, whilst simultaneously verifying to the group that it was something he did like. This part of the discussion illustrates well the key role that sport plays in the construction of 'hegemonic' heterosexual masculinity (Connell, 1987), the power that this 'sex/gender code' (Mac an Ghaill, 1994: 16) has to induce boys to conform, and the penalties that may be faced by those boys who choose to reject it. Many boys may feel ambivalent about being caught up in the masculine culture of sport, and this may help to explain why some of the boys in these interview groups appeared to resent the girls' apparent freedom from sport, giving them (allegedly) more time to invest in their studies.

Like the boys, the girls noted the culture of sport amongst the boys and some recognised it as an aspect of collective gender identity, explaining it in terms of 'tradition', rather than drawing upon notions of individual preference:

> Participant A: Boys are much more I think...boys are more sporty than girls, they tend to be like... "lets play football" and I'd rather sit down and...
> Participant B: If you compared say, a set of ten girls with a set of ten boys, nine out of the ten boys'd be quite athletic and not one of the girls, 'cause like out of this group, there's not one of us who's sort of (laughs) ... into sports at all ...
> (*laughter from group*)
> Participant C: Some of us do swimming, but that's it really
> Participant B: Yeah
> LH: So the boys are more into the sports side of ...?
> Participant D: Think that's just 'cause of tradition as well
> (females, group 2)

Similarly, the over-representation of girls in English and boys in mathematics was explained in terms of tradition:

> Participant A: You also find that nearly all the girls are in English. I think there is ... what is it? Just a couple of boys doing it, out of about twenty or something.
> LH: Would that put you off then, you know if you were going in for a subject where, you know, it was all girls ...
> Participant A: It wouldn't put me off at all no! (*laughs*)
> LH: You wouldn't mind that?
> Participant A: Oh it doesn't bother me like that, no. It's just that it's just sort of tradition really I s'pose. It's like in maths, it's nearly all boys, there's hardly any girls.
> (male, group 3)

Here then, there were signs that the students were aware of the influence of underlying gender norms and expectations, although they did not necessarily employ or have access to terminology such as 'sex stereotyping' to articulate these observations. Explaining differences in terms of 'tradition' was perhaps the way many participants came closest to explicitly acknowledging the presence of structural constraints such as gender-stereotyping. One male participant who was the only boy in his classes studying English and theatre studies, went further than this, implying that the teachers' 'sexist' attitudes had reinforced the sex differentiation in subject choices, by actively encouraging girls in the 'arts' subjects and boys in the 'sciences':

> Participant A: I think definitely in the arts ones girls are more orientated to do well, because the teachers want them to do well and I think in the sciences I think they're more aimed at the guys, but the guys just don't care
> LH: Why? Why do you think that is then... that certain subjects...?
> Participant A: I think it's the teachers
> LH: Right.
> Participant A: I think some of the teachers are very sexist
> LH: What and they're steering you? They're steering you to ... ?
> Participant A: Yeah
> (male, group 5)

Summary: gender in subject choices

The general discussion around subject choice revealed that although participants tended to construe their subject choices as unrelated to gender, they nonetheless demonstrated an awareness, albeit unarticulated, that gender was shaping behaviour and choices. For example, participants were well aware that girls and boys tend to study different subjects and although they personally did not experience this as a constraint, it was clear also from some of the discussions that choosing a non sex-traditional subject can threaten established gender boundaries and call an individual's sexual identity into question. When asked directly about the reasons for their own choices, participants explained these in individualistic terms, based on personal aptitude and preference. However, as interview conversations unfolded, implicit and explicit references were made to wider structures of gender, such as social beliefs about the different abilities of girls and boys, or teachers 'sexist' attitudes. It had appeared to surprise participants of both sexes that girls could achieve in design and technology, revealing the unspoken and taken-for-granted assumption that it is a 'boys' subject. Although they were unaware of it, the participants themselves were actively engaged in reinforcing the sex-stereotyping of subjects by tending to construe subjects in dichotomous terms: difficult/easy, science/art, high-status/low-status and so on, associating the first set of terms with the masculine and the second with the feminine.

When invited to reflect upon the observed sex differentiation in subject choice and preferences, participants oscillated between different types of explanation. There was a contradiction between the predominant construction of choice in individualistic terms and references to the influence of 'tradition' in shaping gendered subject preferences, demonstrating the participants' awareness of structural gender constraints. However, despite this awareness of social pressures to conform to gender stereotypes, there was also a tendency to naturalise the observed sex differences. The almost unanimous agreement that girls work harder than boys do in the years leading to the end of compulsory education also served to reinforce the perception that girls and boys are innately different.

Gender in careers and employment

Career aspirations

One purpose of the group interviews had been to get an idea of the kinds of careers young people were aspiring to, the kinds of things that they were most looking for within a job and the level of interest in engineering. When participants were asked about their career aspirations, the most frequently mentioned career intention was engineering. Eight participants, all male, two from each of the four male groups, expressed an interest in it. The relatively high representation of potential engineers in the groups was not surprising, as those students considering engineering as a career might be expected to be more likely to volunteer to take part, or they may have been asked to do so by a teacher who was aware of their aspirations towards engineering. The second most frequently mentioned career aim was teaching, although this was by only three of the participants - all female. Apart from engineering and teaching, about twenty other careers were mentioned, but in most cases were the intentions of only one or two participants. Other than noting the high level of aspiration towards engineering, it was not possible within such a small sample, to identify any occupations that were particularly popular or to draw meaningful comparisons between the aspirations of males and females. Business studies and computing appeared to be areas of interest to both sexes. One girl and one boy had reversed traditional gender roles - she was considering becoming a fire fighter, whilst he wanted to be a nurse.

Career values

When participants were asked what kinds of things they would most seek in a job, in almost all groups, either money or enjoyment/interest/satisfaction/fulfilment were mentioned first. Typical of responses relating to enjoyment were:

> I'd wanna be able to ... you know, get up in the morning and not think "oh God, I've gotta go to work" (female, group 2).
>
> Keeping me busy and keeping me happy. Like if you're on a nine to five job, you don't wanna be going in going (*sighs heavily to indicate reluctance*) (male, group 5)
>
> I wouldn't wanna get up every morning and hate it "I can't go to work, I don't wanna go to work, I think I'll go to work now", so you have to like the job (female, group 8)
>
> Like I wanna enjoy my job, 'cause at the moment I have a Saturday job. I don't really enjoy it, but it's just to get the money really. I couldn't work in a shop for the rest of my life, I wanna do something I enjoy (female, group 6)

Money and enjoyment were accorded slightly different priorities by males and females, with three of the four female groups mentioning enjoyment, satisfaction or fulfilment first, and three of the four male groups mentioning money first. A range of other job values were also mentioned, including job security, opportunities for promotion, flexible hours, variety, status, autonomy and social contact with others.

Job security appeared to be particularly important to boys. This was mentioned in three of the male groups, whereas it was not mentioned explicitly in any of the female groups, although one girl said that she would like the opportunity for career advancement within a job. Comments relating to job security from the male participants included:

> Participant A: Security. Just make sure everyone couldn't ... like sack everybody and like three weeks time bring in a lot of new ones, or three months time – whatever.
> Participant B: Wanna be guaranteed the job, 'cause say you turned down another job that was just as good, to go to that job, and in a couple of months they let you go or something.
> (males, group 1)
>
> Security in a job ... I mean, I wouldn't be something like a mechanic or something in case all battery cars came in or something. Well, I mean if it's a full career you're gonna decide on, you have to have security. Something like a police officer, well there'll always be police, won't there? (male, group 3).

Although the female participants did not explicitly articulate comments relating to job security at this point in the interview, this nonetheless was of importance to some of the girls. This became evident when later in the interview, some girls expressed their concerns about the negative impact that leaving work to bring up a child could have on some types of jobs (see below).

The work values mentioned by the participants in this part of the discussion were later used to inform the design of the questionnaire (see Chapter 4). Here the work values were presented as items to the larger sample of students. The values they prioritised were then compared with their perceptions of what engineering offers. In this way it was possible to explore the extent to which engineering is or is not considered to offer young people what they are seeking in a career.

'Undesirable' jobs

To assess the degree to which engineering may be considered an undesirable occupation, participants were asked if there were any jobs they *wouldn't* want to do. The most frequently mentioned 'undesirable' occupations were: teacher (both sexes, but mainly boys) nurse (both sexes, but mainly girls), doctor (both sexes, but mainly boys), shop assistant (all girls) and jobs involving waste disposal or cleaning (both sexes). Engineering was not mentioned as an undesirable job. The main reasons the students gave for wanting to avoid these jobs were that they were either low status and/or too much like hard work for the money, they were boring and repetitive or they were stressful. Many participants of both sexes had experience of working as a shop assistant in their weekend jobs and this was mainly perceived as boring, low status and to an extent, low paid. Their experience of this work seemed to have helped them decide that they wanted to aspire to something higher status and more interesting than shop work.

> Participant A: Working in a shop ... I wouldn't mind being a manager or something, but being the day-to-day ... sort of on the shop floor ...
> Participant B: Yeah, I wouldn't like it.
> LH: Is it about status?
> Participant A: Kind of, but ...
> Participant B: It's just not a good job
> Participant A: It's because if you're a manager, you can do so many things and you can change the way that people are treated ... I can't explain it ... when you're on the shop floor, it's fine, there's nothing wrong with it at all, but you're kind of under the thumb.
> (females, group 2)
>
> I wouldn't wanna work in a shop, be a sales assistant, 'cause I mean, I do that on Saturdays and I couldn't hack that five or six days a week ... it just doesn't vary enough. You sell different things and you have to know product knowledge but it doesn't change enough, doesn't vary enough.
> (female, group 4)

The main reasons the boys did not want to go into teaching were either that they didn't like 'kids' or they felt that teachers are under pressure because they are given such a hard time from pupils (including themselves):

> Participant A: Well, look at the stick we gave the teachers
> (*laughter from group*)
> Participant B: The headmaster shouting and you could hear in parts of the school
> (males, group 1)

Some of the also girls shared this view:

> Participant A: I couldn't be a teacher
> LH: Why couldn't you be a teacher?
> Participant A: Dunno, just sort of too much ...
> Participant B: Hate kids!
> (*laughter from group*)
> Participant C: Yeah!
> LH: Yeah, the boys said that as well (*laughing*)

Participant B: Kids are just so ...
Participant C: Anything about thirteen and under I just don't like
(laughter from group)
LH: The boys said that as well, then they put it up to seventeen!
Participant A: No, teaching just seems too stressful ... my mum's a teacher, she's always stressed out.
(females, group 6)

It was clear that there were strong feelings of negativity towards low status jobs of a routine or manual nature. Equally, however, many participants also held negative views towards some higher status careers, such as medicine, nursing and teaching, some because they were squeamish or felt they were not suited to it, but others because they felt that these jobs are very hard work, for little financial reward. Teaching also aroused strong feelings of negativity, as illustrated in the comments above, but at the same time, it was one of the most frequently mentioned career aims amongst the participants.

Non -'sex-traditional' occupations

One explanation for the low participation of women in engineering is the widely held view is that young people are not attracted to occupations that have been traditionally performed by the other sex. For example, in a news release by the Equal Opportunities Commission relating to vocational choices in schools, the Deputy Chair of the EOC argued

> Outdated ideas about what is 'women's work' or 'men's work' seem to have far too much influence on the subject choices young people make (EOC, 2001c)

To find out if students would be discouraged from choosing certain occupations because they are dominated by one sex (for example, nursing or engineering), participants were asked how they would feel about being the only person of their sex in a job. Overall, participants' responses were mixed and often contradictory. In most of the groups, those participants who replied first gave answers to the effect that it would make no difference to them, typical examples were:

> I'd love it! (male, group 5)

Participant A: I'd find it quite a laugh
Participant B: Yeah, it wouldn't bother me (female participants, group 2)

Wouldn't bother me at all (female, group 6)

Within groups of both sexes, but in the male groups particularly, this initial response appeared to serve for some participants as way of verifying their heterosexual identity within the peer group. It was often only after doing this that the same participants felt secure enough to articulate some reasons for being less enthusiastic about working with the opposite sex.

Other participants took a more measured approach and qualified their responses in terms of the type of job they might be doing:

I think it depends on the job (male, group 7)

It depends what job you were doing though (female, group 8)

I think it depends definitely what kind of job you're in and what level of intelligence it requires. If you're in, if you're sort of an engineer and you're the only female - God it's gonna' be difficult! (female, group 2)

This latter participant may well have linked her response to the engineering issue as a result of her awareness that the research was concerned with exploring views on the barriers to women in engineering.

For some participants of both sexes, the willingness to work in an occupation dominated by the opposite sex would depend on how they were treated by their work colleagues:

Wouldn't bother me...long as they didn't like sort of make it stand out that you were a boy, and you didn't deserve to be there (male, group 1)

It depends what they treat you like - if you're treated as...well...the same, or if you're thought of as "oh you're a woman and you can't do anything" - get stuffed really, but...
(female, group 4)

A few participants of both sexes admitted they were not keen on the idea of being the only member of their own sex at work:

> Participant A: Actually, I wouldn't like to work in a job where it's all boys - well men
> LH: Wouldn't you?
> Participant B: Yeah, I agree.
> Participant A: I'd prefer mixed, because that's how it's been for like most of my life, you been taught with boys *and* girls. (males, group 1)

> Participant A: I wouldn't really (*like it*) I don't think
> Participant B: No
> LH: You would prefer it if it was...?
> Participant A: Maybe one other female (*laughs*), 'cos you can't really, like, talk to blokes (females, group 6)

Other participants of both sexes held negative views about working with women. One of the male participants works in a clothes shop on Saturdays, where he is the only man. He said he didn't like working with women because he thought they were 'bitchy':

> Participant A: They're always ill and things, I don't like it. I don't enjoy working with women
> LH: Don't you?
> Participant A: No, not at all. They all bitch behind each other's backs. Well this is in general, they often bitch - and they've always got something to whinge about
> (male, group 3)

Female participants in two of the groups shared his view about women being 'bitchy', and said they prefer to work with males:

> Participant A: Yeah, I'd prefer to work with males...'cause I work in menswear at the moment and they're sort of less hassle
> LH: Right, you work with men?
> Participant A: Yeah, there's like, a few girls and we get on really well, but men sort of...they don't seem to...like...there's no bitchiness or nothing ...it's just sort of generally a more relaxed atmosphere - there's no real tension and if you can't reach something you just get them and...
> (female, group 8)

> Participant A: Yeah, I think you have more of a laugh and there's a better environment with just the blokes...
> Participant B: It depends
> Participant A: 'Cause working with like a great big group of girls, they're *so* bitchy
> Participant C: Yeah, yeah, they are, they are!
> Participant A: And they're like... "have you seen her hair?" "have you seen her..." and you just think "Oh God!"
> (females, group 2)

It is of interest to note that this second group of girls made a 'they/we' distinction, between what other girls do and what they themselves do. This 'distancing' strategy has been noted elsewhere (Henwood, 1999; Hughes, 2001), as a means of taking up legitimate feminine identities that are 'other' to dominant versions of femininity. In this particular context, the girls were distancing themselves from other young women in order to position themselves as innocent of the tendency to 'bitch', and therefore as different from 'typical' women. The point worth making here is that this strategy does nothing to challenge the dominant conception of females as 'bitchy', in fact, it serves to reinforce it.

Some of the female participants appeared to be uncomfortable with this question about whether they would be prepared to work in a male-dominated environment, and gave responses in defence of men:

> Participant A: I don't think there's any difference
> Participant B: Some of my best friends are blokes
> Participant C: Yeah
> Participant D: Yeah
> Participant C: I used to be in the Air Cadets and for a month I was the only girl there with about thirty two lads... (*laughter from group*) ... but they just make you part of them really, it's just...you're just as like...you're one of them
> (females, group 6)

Other girls, however, were more negative about working with men and gave examples of the sexism they had experienced as the only woman at work:

> Participant A: Where I work... it used to be me and all male Saturday staff upstairs and they were a pain
> LH: What were the kind of disadvantages then, with that?
> Participant A: Well, because we sell all camping gear, the men think that they can put all the tents up and I will just sell all the nice, light things (*laughter from group*). They don't have a clue, despite the fact that I do Duke of Edinburgh at the moment and I know more than they do about it. They still think...you know, I'm a girl, I can't put a tent up - things like that.
> Participant B: No, you just like split into two. It's like...where I work in a sports shop as well, the customers would rather go up and ask a man where anything is
> (females, group 4)

One female participant spoke about her sister's experience of being the only woman doing mechanical engineering in the army:

> She's the only girl doing the course and they were really...you know... wouldn't involve her at the beginning, but now they've accepted her into it. She's proved that she's capable of doing it (female, group 4)

There were evidently some contradictions in the participants' responses to the question relating to non 'sex-traditional' occupations. Although many participants denied that they would have a problem working in an occupation dominated by the opposite sex, it was clear from some of the discussions that some participants had first-hand experience of some of the issues that can arise in work groups where one sex is dominant. On the whole, most participants preferred a mixed-sex working environment. The participants' desire to support equal opportunities did not sit easily with their knowledge that women and men are not treated equally in practice. The female participant who had been in the Air Cadets and the one whose sister was an engineer in the army both accepted that women have to *prove* themselves and earn acceptance by men. Comments such as this tend to unwittingly reinforce the perception of occupations such as engineering as masculine, and illustrate well the fact that while women may be 'free' to enter such occupations, they can only 'succeed' in them on men's terms (see also Henwood, 1999).

Perceptions of the 'sex-appropriateness' of occupations

To explore the extent to which students' own views about men's and women's occupational roles might be 'stereotyped', participants were asked if they thought that their own sex is better suited to some jobs than the opposite sex. On first hearing the question, about half of all the participants said 'yes' and the other half 'no'. Of those participants who did think that some jobs were more appropriate for one sex than the other, the type of work which was mentioned most frequently was manual labour - boys in all of the male groups and girls in half of the female groups said that men are better suited to manual labour than women:

Well, builders - you rarely find women builders do you? 'cos they're not as strong in general as men (male, group 5)

Women would be hopeless having to do manual labour (female, group 4)

Participant A: Builders! You don't see many women builders, do you?
Participant B: All lesbians!
(laughter from group)
(females, group 6)

In one male group, there was an obvious tension between a view naturalising differences between the sexes and a desire to be 'politically correct':

LH: Do you think that men are better suited to some kinds of work than women are?
Participant A: Yes
Participant B: Heavy labour and things like that because ... it's not a sexist thing, it's just a fact of life that men's bodies are built stronger frames than women ... well, on the whole.
Participant C: Some research done said that men kind of concentrate on one thing more and women are more general, so ... so that would possibly suggest that men are like ... better for top jobs, 'cause they like ... drive to push it forward.
LH: So you think that suggests that they're more focused?
Participant C: Yeah, it's not like a personal opinion, yeah, men are more focused.
(males, group 1)

The use of caveats, such as 'it's not a sexist thing', 'it's not like a personal opinion' revealed the boys' desire not to appear unsupportive of an equal opportunities view, which may well indicate a reactivity effect towards a female interviewer discussing gender issues.

Some participants' replies indicated that they were uncomfortable with any generalisations about women or men being better at particular types of work than the opposite sex. They tended to 'neutralise' gender, viewing career choice as a matter of individual preference, unrelated to gender, or they used the 'equal opportunities discourse', giving examples of how men or women are equally capable of doing jobs that have traditionally been dominated by the opposite sex:

I think it doesn't matter what sex you are, you can do any job you want (male, group 5)

It depends. See some blokes would be good at...it's like...when I worked in the Bodyshop there was like blokes in there (*in a slightly camp voice*) doing all the perfume an' that.
(laughter from group)
(female, group 4)

This latter response was very telling in its contradictions. On the one hand, the participant was saying that men *can* do jobs traditionally performed by women, but on the other, she was also implying that a man working in the beauty industry would be somehow 'different' from other men, i.e. he would be more 'feminine', camp or perhaps homosexual. This comment and the earlier one relating to female builders, serves to illustrate the implicit investment of gender and sexual identities within particular occupational categories. Sexuality is clearly an integral part of the construction of subject disciplines and occupations, and in making a 'cross-gender' subject or career choice, one's sexual identity can be called in to question by the peer group (Measor, 1983). In her parody of effeminacy in relation to males working in the Bodyshop, the participant in the above extract was constructing the job within a specific and minority masculine identity, and in so doing, ruling it out as an appropriate occupation for males conforming to dominant versions of masculinity.

The next two comments serve to illustrate the way that two of the female participants were struggling with competing discourses in relation to the gender imbalances in 'caring' occupations.

> I think it's personality myself, 'cos some men have got the personality to work with...say ill people, some women haven't. Like to a certain extent I'd be able to work with sick people but after a while I'd find it just really annoying - I know that's mean but that's just my personality (female, group 2)

> I think maybe, um, being like a social worker or something, I don't know, maybe they (*women*) would be a bit more in tune with a person's feelings, but then a bloke could just be exactly the same (female, group 6)

On the one hand these girls were well aware of the discourse that says that women are, and *should* be, caring by nature, hence better suited to these jobs, to the extent that the first participant felt bound to apologise for not wanting to work with sick people. At the same time as recognising the broader stereotyping of these jobs as 'feminine', they constructed career choices towards caring work within the discourse of individuality, again negating the impact of gender.

Many participants of both sexes were clearly uncomfortable with 'sexual difference' explanations and some of these demonstrated an awareness of structural factors, including stereotypical ideas about what kinds of jobs women and men should do:

> I just don't think women are like...um...accepted into those kind of jobs - that's why they don't go into them (female, group 6)
>
> Do you think that might be because they haven't had the chance, rather than...? (male, group 5)
>
> This shouldn't happen but it does - you'll get like people who'll stereotype that - employers now, still however much they don't want to, they just can't help it (male, group 5)
>
> Tradition I think ... there's certain jobs for men and certain jobs for women (male, group 3)
>
> It's like with teachers, say if you had a primary teacher and it was a woman and she put her arm round a child - there wouldn't be a problem. But if a bloke did it then he could ... like I know somebody who got done for sexual harass...harassment (male, group 7)

When asked what they considered to be stereotypically 'women's work', the occupation most frequently mentioned by participants of both sexes was 'secretary', followed by 'nanny, then 'nurse'. Although they may not have had access to the terminology, many of the participants were able to reflect upon the existence of sex-stereotyping and social expectations in relation to 'men's' and 'women's' work:

> Participant A: I think it's the way it's labelled as well, sort of like...if it's something like 'secretary' then...
> Participant B: You see woman, don't you?
> Participant A: Yeah, whereas if it was 'PA' or something, then a man would probably...
> Participant B: Yeah
> (females, group 2)
>
> But you don't think of men as nurses, or becoming hairdressers, but it's well known that some of the top hairdressers are... (female, group 4)
>
> You would *expect* men to go in the army and you would *expect* them to do like roofing and bricklaying and working on cars (female, group 4)

Although these female participants were aware of some of the oppressive effects of gender-stereotyping, some simultaneously agreed that they did think men were better suited to positions of authority than women, because people, including themselves, don't take women seriously:

> Participant A: I think that as well...men are like...more threatening and stuff - as policemen and things like that
> LH: You think they have more...kind of...authority?
> Yeah (*several voices*)
> Participant A: 'Cos like, if you see a woman, perhaps come up to you and say "stop that" - it's like "oooh" (*mocking voice*)
> (*laughter from group*)
> (females, group 4)

While drawing on essentialist ideas of femininity, these same female participants were simultaneously critically aware of women's structural disadvantage in the labour market:

> Participant A: Where do you see a man filing? (*laughter from group*) Cups of teas? You see 'em ordering 'em, but you don't see 'em getting them.
> Participant B: It's like second class jobs innit, for women? ... they get like to sort of assist
> (females, group 4)

Other participants, both male and female, expressed the view that the positions of women and men are becoming more equal:

> But I think a lot more now with computers and office work it's a lot less gender-orientated, I think (male, group 7)
>
> Participant A: S'like you're getting more women managers and engineers
> LH: Yeah?
> Participant A: And certainly it is more three quarter men, one quarter women in engineering courses, but it's getting more ... even now - there's been a big push
> (male, group 5)
>
> Participant A: Statisticians are starting to show that positions of power, well, not power, but...you know, are being more to like given to women and they tend to be studying more and like increasing their knowledge so...
> LH: Mmm
> Participant A: I think it is starting to like...even out a little bit more
> (female, group 8)

Summary: gender in careers and employment

As with the discussion of subject choices, competing discourses were evident in the participants' conversations around careers and occupations. It was clear that the discourse of individuality and equal opportunity favoured by the participants did not sit comfortably with their less immediate awareness of the way that gender has an impact on the occupations chosen and performed by women and men. While the impact of gender was frequently negated by participants in favour of individual and equal opportunities views, gender often appeared in indirect ways, either in essentialist assumptions about what males and females are capable of, or in participants' indirect references to the presence and impact of stereotyped assumptions about what males and females are capable of. Engineering did not appear to arouse strong feelings either for or against it as a career option. However, the participants' preference for a mixed-sex working environment is unlikely to make it a popular choice with either sex, but particularly girls who were aware of the need to 'prove' themselves in a male dominated environment. As far as work values were concerned, on the whole the participants most valued high earnings, enjoyment and security in any future career and it was of interest to explore further whether engineering was perceived to offer these things.

Gender in engineering

Intentions to pursue engineering as a career

Participants were asked if they were considering going into engineering, although what was meant by 'engineering' was deliberately left unspecified in the question, to allow participants to define its meaning for themselves. Two boys from each of the four groups expressed an intention to go into engineering careers, representing 14% of focus group participants. No girls intended to pursue engineering, although one had considered going into the RAF as an engineer before she began her GCSEs. She had changed her mind after doing electronics at GCSE, which, she said she "just couldn't handle". As mentioned earlier, it was possible that a higher number of participants in this study expressed aspirations towards engineering than would in a different context, because they were aware that the research was about engineering. In consequence students interested in engineering may have been more likely to volunteer themselves as participants. There may also have been some 'social desirability bias' (Oppenheim, 1992; Robson, 1993) in the sense that participants may have thought that an intention to go into engineering would be approved of in the context of this study.

Relatives/friends in engineering

Previous studies suggest that connections with an engineer are a predictor of choosing engineering as a career (Woolnough, 1994 and 1997; Foskett and Hemsley-Brown, 1997). In this investigation, participants were asked if they had any relatives or friends in engineering in order to find out if this would make a difference to their level of knowledge of engineering and/or their intentions to pursue it as a career. Within this small group of participants, some connections between family background and intentions towards engineering were found, although these are not generalisable. One of the eight participants who intended going into engineering had a father who was a civil engineer and two others had relatives who were engineers at British Aerospace in Bristol. Some participants were unclear about whether their relatives were engineers or not, or tended to construe engineering as synonymous with manual occupations such as maintenance worker and car mechanic.

> My dad's a heating engineer (female, group 2)
>
> Well my dad's sort of officially a mechanical engineer, being a lecturer in the CFE (*College of Further Education*), but he's a mechanic (*laughs*). He used to be a mechanic, he lectures in it, so ... basically I've seen him, he just fixes cars an' that, so I'm going off of that ... and he's always had bits lying around the house, so ... (male, group 3)

Asking this question revealed that many participants did not know what engineering is and needed clarification:

I'm not sure what engineering actually entails (female, group 2)

So what do you mean by engineering? Do you mean like, electrical? (female, group 8)

What *is* engineering? (female, group 4)

These findings support those of Foskett and Hemsley Brown (1997), who also found that many of the students in their survey did not know what engineering was. In this regard, Bronzini et al. (1995) have claimed that 'most people simply do not know what [...] engineering is. Worse, those who think they do, have negative and incorrect images of the field' (cited in Foskett and Hemsley Brown, 1997: 58). It is also worth noting that in this study, all those who asked for clarification as to what engineering was were female. Many of the male participants may not have been sure about engineering either, but they did not openly admit this.

The status of engineering

Some commentators have linked the current recruitment difficulties in British engineering with the widely held perception of engineering as a low status occupation (Glover and Kelly, 1987; Macdonald, 1995; Smith and Whalley, 1995; Foskett and Hemsley-Brown, 1997). It was therefore useful to further explore the general perception of the profession amongst this group of young people. In an attempt to elicit participants' perceptions of engineering, they were asked *"If someone says they're an engineer, what do you imagine they do?"*. In response to this question, many respondents said they didn't know, although nearly all of these were female. Where answers were given, male respondents most associated engineers with machines and designing, whilst females more often gave more responses which conjured up a low status, manual labour image of engineering. They often conflated the occupation 'engineer' with 'mechanic', and associated engineering with tools, overalls, oil, grease and factories.

Participant A: Overalls and boilers
Participant B: Grease
LH: Dirt?
Participant B: Big sort of plans and you know, I don't know
Participant C: You're going there Claire, go on
(*laughter from group*)
(females, group 4)

Participant A: I think of a car, mechanic kind of thing, but ...
Participant B: Yeah, I think of engines, because of the word
(females, group 2)

I don't know why, I just think of a big huge factory (female, group 6)

This image of engineering is likely to make it unattractive to participants, given that, as was evident earlier in the chapter, low status, manual jobs are considered undesirable. Not all participants perceived engineering in this way however. Participants of both sexes linked engineering and computers and many also saw engineering as an occupation encompassing a wide variety of specialisms and a job hierarchy from manual labourer at the bottom to professional worker at the top.

There's different types of engineer though isn't there? 'Cause you've got like sound engineer and computers and there's all that British Aerospace, most of them are engineers, so there's so many different type of jobs (female, group 8)

Participant A: Well I think of a scientific engineer. Is there such a thing as a scientific engineer?
LH: Sure yes.
Participant A: or other types ... any type of engineer and then I think of a mechanic or something. I imagine the other end to be really rich, even though a mechanic could be rich – you know
LH: So you think of it as quite a broad ...
Participant A: Mmm it's like a big spectrum, yeah
(female, group 2)

To assess further whether engineers were primarily regarded by these young people as highly qualified professionals, or as less educated, lower status workers, or both, the students were asked if they knew how a person might go about becoming an engineer. Responses to this question indicated that most participants were aware that there are several routes to an engineering career and that these can be at different academic levels. Those routes mentioned by participants were degree study, the Year in Industry scheme, apprenticeships, and GNVQ courses.

LH: And how does a person become an engineer – how do they go about it?

Participant A: All sorts of ways aren't there? Get a degree in it.
LH: Which ways are there?
Participant B: Can become an engineer on an apprenticeship, as in work in a company like John was saying, or you can get a degree and go for a company that way.
(males, group 3)

However, this question did not elicit as much interest or information on the perceived status of engineers as the previous question where participants were asked what they thought engineers do in their work. It was also limited because many participants had already picked up some information about engineering education from those in the groups who intended going into it, or because they knew GNVQ engineering was on offer in their schools. It was therefore difficult to tell whether or not participants were guessing their answers.

The masculinity of engineering

The low status perception of engineering amongst some participants is likely to have class connotations, given that middle-class students may well avoid it in preference for higher status occupations. As expected, there were also gender connotations, as it was clear that the association between engineering and masculinity had not gone unnoticed. Many of the participants were aware that engineering is an occupation traditionally performed by men:

Participant A: Definitely a man thing
(*several voices*) Yeah
LH: It's a man thing?
Participant A: Yeah, stay that way as well! (*laughs*)
Participant B: That's why ... if you get a lady that wants to do it, that's why it's so hard to actually get accepted into it, 'cause it's always gonna be seen as a man's job
(females, group 4)

Participant A: Traditionally it's all male.
Participant B: Yeah, you think ... aeronautical engineering ... the workshop floor of British Aerospace or something, you can imagine it being hugely male orientated
Participant C: A bloke who did work experience, he knows about one woman and forty blokes
LH: Yeah?
Participant A: But they're running all these drives to get women into it aren't they?
LH: Yeah
Participant A: 'Cause it's sort of seen as male work
(males, group 7)

Participant A: It's quite male-dominated. I don't know why, it's just ...
LH: Men's work?
Participant A: No, it's *not* men's work, but that's what it's ...
LH: It is male-dominated yeah.

(male, group 1)

Clearly, male participants as well as females had felt that the male-dominated nature of engineering was noteworthy. However, whereas the female group focused on the negative consequences of this for women, the male participants seemed to be more concerned about emphasising the fact that engineering *shouldn't* be seen as male work and that initiatives to increase the participation of women are changing this situation. Again these responses may have been due, in part, to social desirability bias and the desire to 'say the right thing' to a female researcher clearly interested in gender issues.

Factors which may attract young people to engineering

In order to identify any potential factors that may attract young people to engineering careers, participants were asked which types of engineering seem the most interesting, attractive or glamorous. Less than half of the participants responded to this question, which did not stimulate much discussion because most participants had limited knowledge of engineering, or were just not interested in discussing it. Of those who did respond, mechanical and aeronautical engineering tended to be the most appealing to males and civil engineering to females. Both sexes expressed an interest in computers, communications, aerospace and genetic engineering. Of the remaining participants, some of the girls said that they didn't know enough about engineering to comment and some of the boys said that it is a matter of personal preference. This question served to illustrate how little the participants knew of the day-to-day work of engineers.

The social value of engineering

In order to find out whether participants were generally positive or negative towards engineering, they were asked if they thought that some types of engineering were more useful to society than others. There was some ambiguity around the word 'useful' in the question and this often needed to be re-defined as 'important' or 'beneficial' in order to tap into the values held by participants.

> Participant A: Well, I think we'd be a bit lost without our lights (*laughter from group*) and sound and like, TV engineers and ...
> Participant B: You can have like ... genetic engineering, can't you?
> Participant C: People working in laboratories, yeah
> Participant B: That would be quite interesting
> Participant C: That's all to do with medicine isn't it?
> Participant B: Yeah
> LH: So yeah, medical engineering then is one?
> Participant B: I'd say that is important
> Participant A: But if you're talking about 'useful' then probably just people who like mend stuff (*laughter from group*)
> (females, group 8)

Another limitation with this question, as with the previous one, was that most participants had insufficient knowledge of engineering and its applications to formulate strong opinions either way. Participants tended to either identify a particular type of engineering or technology as being more useful, or to argue that all types are equally useful. There was no consensus on which type of engineering might be the most important or useful.

Responses can also be divided into those expressing a positive attitude towards engineering and science and technology in general, and those expressing a negative attitude, although many of the participants simultaneously expressed both positive *and* negative views of technology. Positive perspectives on technology were dominant and it was necessary with half of the groups (both sexes) to prompt them for any negative views by asking if they felt there were any types of engineering which might be 'bad' for society. Examples of positive views are typified by the following comments:

> For the advancement of a society we also need engineering and technology (female, group 2)
>
> Most of it's got its use 'asn't it? You could say all of it's got its use somewhere (male, group 3)
>
> Everything relies on it (*engineering*), doesn't it? (female, group 4)
>
> An engineer - any aspect, would help society (male, group 5)

Answers here were rather vague however, indicating a lack of awareness about engineering and a possible desire to 'say the right thing' to the interviewer.

Negativity towards engineering was mainly expressed in terms of debates around genetic engineering, which appeared to be the most salient type of 'engineering', certainly for the female participants, where the subject was raised in every group, although many would argue that this is a misinterpretation of what engineering is and is better classified as pure science:

> But I don't think we need like, genetical engineers and stuff like that... I just think it's messing about with stuff we don't need to know about (female, group 2)
>
> Like um, cloning, I know it's probably nothing to do with it, but, I think it's gone, like, too far, stuff like that (female, group 4)
>
> LH: Are there any negative aspects?
> Participant A: In genetic engineering
> Participant B: Can be. It can be very beneficial depending on what they do. They could cause an absolute world disaster if they weren't careful, but if they were careful, they could, like, kill off AIDS and stuff. It's just finding that breakthrough and depending on cloning and how mad the guy is...
> Participant A: It depends who's like universally in control I s'pose, doesn't it?
> Participant B: Like, if he was a guy who didn't care anything about the world, just cared about profit, that would be dangerous
> (males, group 5)
>
> Participant A: They all (engineers) play their part in it, don't they really? ... except the ones that engineer stupid sheep or whatever (laughter from group)
> Participant B: I think that's totally wrong
> (females, group 6)

Whilst most female participants were negative about genetic engineering, two girls, who were better informed, found it interesting and believed it could be potentially beneficial for society. Other negative views about engineering were linked to the impact of technology on employment, female employment in particular:

> Participant A: Well, if you make things then they'll ... like with computers, yeah? You've got technology which makes them so much better, so the people who would have obviously done it before - secretaries, something like that - then you lose sort of jobs like that which are for women...
> Participant B: Yeah, it's like computers are upgrading all the time so you gotta learn what the things are and it's making your job harder and if you don't know it 'cause it has just been upgraded, then you're thought "oh, you're not that good for the job" so huh!
> (females, group 4)

The 'invisibility' of engineering

On the whole, it was difficult to draw participants out on the issues relating to engineering and there was a general feeling of indifference and boredom towards the topic amongst most of the groups. This may have been because many of the students felt they did not know enough about engineering to comment. Related to this lack of knowledge, one theme that emerged when questioning participants about engineering was the 'invisibility' of engineering amongst the students. Some of the female participants felt that it was difficult for them to comment on engineering as they felt they knew little about it, because engineering is something that goes on 'unnoticed' in the background:

> I think that there's a lot of engineering that you don't see, so you don't think of it as important, 'cause that's like the background of it, you don't see it, but it's probably still important to everyone (female, group 2)
>
> Yeah, you'd be able to... if someone said like office work... you'd be able to say what it is, but engineering's not very... like you could give examples of office sort of jobs (female, group 2)

The invisibility of engineering is also an issue in the sense that certain aspects of engineering, such as the role of a graduate engineer, are less visible to young people than other images such as 'fixing', 'building', 'working with the hands' and so on. Foskett and Hemsley-Brown (1997), for example, have argued that more academic students may be negative towards engineering because the 'intellectual' components of engineering are not immediately visible to young people, whereas the practical aspects are. They claim that not only do the manual connotations of engineering contribute to its low status amongst young people, but also that the students they interviewed found it difficult to understand why someone who is academic would do a manual job:

> Engineering is the worst of all worlds for many students who like to categorise themselves as academic rather than practical and either creative or scientific – but not all of these things. Part of the process of trying to be more academic seems to be to reject anything practical (Foskett and Hemsley-Brown, 1997: 65).

In relation to this point, it was worthy of note that one female participant, whose father had qualified as an engineer and was now a manager in an engineering firm, no longer classified him as an engineer, because his job did not entail working 'on the tools':

> My dad's been an engineer, but he's not any more, 'cos he doesn't do the actual... on the tools - he's in charge of all the people. But he used to be, he's qualified as an engineer (group 2)

Clearly, for this latter participant, the practical and the intellectual could not be reconciled in one job. Engineers are people who work with their hands and cease to be engineers once they move into a supervisory or management role.

Beliefs about women's 'suitability' for engineering

When asked whether women might be better at particular types of engineering work, participants' responses were split again (as they had been earlier in the interview when asked about subject ability), between those who were prepared to affirm sexual difference and those who denied it, or at least were reluctant to generalise. More than half of the participants presented an equal opportunities view, saying they did not think there would, or *should* be any difference between the sexes. Some of these participants drew on the discourse of individuality, arguing that individual personality and aptitude is a more important factor than a person's sex in their suitability for tasks.

> I still think it's personality and your own sort of ... what you're really interested in that makes a difference (female, group 2)

> Participant A: I don't think you can generalise too much about things like that
> Participant B: Yeah, 'cause everybody's different, you know, we're all good at different things, got different qualities and that sort of thing, so you can't just say "oh women will all be good at you know, better at that"
> (females, group 8)

Of those who were prepared to identify areas of engineering work that females may be suited to, participants of both sexes suggested that women might be good at engineering design and the creative side of the work, reinforcing the link between femininity and creativity. Some of the male participants suggested that women would be better at tasks for which one does not need to be physically strong. These included abstract theoretical tasks as opposed to 'work on bridges' and work involving computers.

> You don't need to be like ... strong or anything to use a computer do you? (male, group 1)
>
> I dunno, I think women could do mechanical engineering, 'cause there's not really much strenuous work. It can be, but it's not really, it's just about being good with your hands really (male, group 7)
>
> Participant A: I think they'd be good at design myself, design'd be no problem would it? Don't matter whether it's a boy or a girl.
> Participant B: They'd be dropping women's cards around and stuff
> Participant A: They'd be all pink!
> (*mocking laughter from group*)
> (males, group 3)

Although in theory, this latter group of participants were supportive of women in engineering, in ridiculing the idea of women engineers having business cards, they revealed that the idea of women in engineering was one they found difficult to take seriously and was possibly threatening to them.

Awareness of barriers to women in engineering

When participants were asked if they thought women going into engineering would face any particular challenges or difficulties, every group of participants referred to the fact that engineering is male-dominated and saw this as a problem for women. The most frequently mentioned (by both sexes) problem which women in engineering might face, was male hostility and sexism:

> You'd have all the mechanics, the blokes, who think that's the men's job, so women would have problems fitting in there (male, group 3)
>
> In some places, not all...sense of ridicule or something (female, group 2)
>
> Well, ...if they're on a site, unless they're like the top dog person there, they will find that some of the lower people give a bit of ... grief. They... 'cos that's the way builders and that sort of workers are (laughs) (male, group 5)
>
> The comments and things you'd be faced with as well - you'd have to be strong enough (female, group 8)
>
> Probably some... you know, a bit of sexism, 'cos they're all blokes (female, group 6)

Some of the girls were aware of the difficulties that women might have in entering engineering, having already encountered at first hand hostility from boys in their school in relation to the girls' relative academic success:

> Participant A: If you're better than them, they hate it, 'cause then ...
> Participant B: They hate other people ... well ... women, being more authoritative than them. They can't handle it. It's weird really, 'cause we do so much better at school than they did, which is quite strange.
> LH: And do you think that girls can handle having a male boss better than blokes can handle ...
> Participant B: 'Cause males are so competitive about everything ... you know ... they can't take it! (females, group 6)

Other potential challenges or difficulties for women in engineering were raised mainly by female participants. One was the fact that women would not be taken seriously as engineers:

> If like a customer asked you, they might ask a second opinion off a man (female, group 2)
>
> Not looked at as equal, sort of thing. Looked at as something different - as 'you can't do that job', so, I'm not gonna bother and make you do it, sort of thing (female, group 4)
>
> Just to be recognised ... I mean, if you get located to do just cars, while the men are doing... I don't know - aeroplanes and stuff like that (female, group 2)

Another problem mentioned was potential discrimination by employers:

> I mean, a lot of the engineers...they'll virtually all be male anyway. They'll have had male engineers, so a female engineer they wouldn't look at (female, group 4)
>
> It'd be like quite old-fashioned, like bosses and that, they don't like the idea of working alongside a woman in a man's job (female, group 8)
>
> I think it depends on like ... where you go and the attitudes of the people who're already there. It's like if there's quite a lot of old-fashioned people there, it's like... "oh you don't belong here" (male, group 1)

The 'anti-female attitudes of employers' was also a theme that emerged in Bryant's (1984a) study of female engineering students, many of whom believed that they would be viewed by potential employers as unsuited to engineering, or that employers would assume they were likely to take a break to raise a family. Although the young women in the present study were younger than Bryant's female undergraduates, the difficulties of combining a career in engineering with family life had been considered by participants in two of the groups, who raised the issue of the potential conflicts between being an engineer and a mother:

> Participant A: 'Cos like, if women like, have kids or something, then it's not really... you can't really sort of like plan your kids around engineering, it's kind of really job-orientated
> LH: That's interesting. So you think it might be kind of harder to combine having a family with that kind of job than it would...?
> Participant A: Mmm, 'cos it's like, really professional and highly paid and stuff like that
> Participant B: I was just going to say that, 'cos it's moving forward all the time, isn't it, technology and that. If you like take a couple of years off to have some kids and stuff, you know, you'd be completely out of touch
> LH: Mmm. And you think it may not be that bad in other professions?
> Participant B: Um, well, some things I s'pose, like teaching and nursing and things like that, perhaps where you could go part-time and things like that
> (females, group 4)

> Participant A: If you're gonna go into a career like that, that's so like intense and you have to work really hard and everything, is when you... if you want to start a family or have a baby or anything, you have to decide whether you wanna put your career on hold or...
> LH: Whereas perhaps with other careers it might be easier to do that?
> Participant A: Mmm. It's easier to like take a break and then go back and still be in the same position.
> LH: Yeah, so if you did that, perhaps if you were in engineering when you did that, you might get left behind?
> Participant A: Yeah
> Participant B: You might have to start from, you know, start from scratch again
> Participant A: 'Cos the technology had changed
> Participant C: I think in a way that happens a lot. Um where I work, one of the product managers became pregnant and our assistant manager left and our manager said if she hadn't of become pregnant she would have been promoted.
> LH: Yeah?
> Participant C: So I think that happens a lot, but if you're in something where things are changing all the time and you take a break, then you do miss out on ...
> LH: And you think that engineering is an area perhaps where there's a lot of change very quickly?
> Mmm (*several voices*)
> (females, group 8)

The participants in both of these groups perceived engineering as incompatible with motherhood because they believed it to be an occupation that requires a high level of commitment and is therefore 'family unfriendly'. They also believed the pace of technological change would disadvantage women engineers who took career breaks. Back in the 1980s, Byrant (1984a: 21) found that the young women in her study saw the 'penalties for taking a break in their work lives as considerable enough to cause a considerable proportion of them to plan not to have children at all, and to cause the others to see these two aspects of their future lives as separate and to an extent incompatible'. Twenty years on, little seems to have changed in this regard and there is strong evidence to suggest that girls who envisage becoming mothers in the future are likely to avoid occupations like engineering in favour of more flexible, family friendly occupations. Blackwell's (2001) analysis of LS data found that there were distinct differences in patterns of family-building between female graduates in the natural sciences and technology on the one hand, and non-scientific graduates on the other. 'Highly qualified women scientists and technologists were less likely to marry and have children than those highly qualified in other subjects, including health' and those 'those working in technology and in natural science were the least likely to have children' (Blackwell, 2001: 9).

Summary: gender in engineering

Strong patterns emerging from some of the groups in the discussion around engineering were confusion about what engineering is and a tendency to construe it as a low status manual occupation. Some participants did, however, perceive engineering as a professional 'scientific' occupation. In relation to the confusion or lack of awareness about engineering, some participants mentioned the 'invisibility' of engineering in their daily lives. Responses to questions about the social value of engineering and other factors that may attract young people towards it were mainly inconclusive, and this must be attributed in part, to the participants' general indifference towards the topic. In relation to questions about women's roles in engineering, competing discourses were again evident, as they had been with the earlier interview topics. On the one hand there was a denial of sexual difference in favour of individualist and equal opportunities views, but on the other hand there were essentialist assumptions about females' unsuitability for 'strenuous' engineering work. Finally, participants of both sexes were strongly aware of some of the barriers faced by women working in engineering, particularly those of male hostility, sex-discrimination and the difficulty of combining the responsibilities of motherhood with work in such a 'family unfriendly' occupation.

Chapter summary and conclusion

This Chapter has presented data from semi-structured focus group interviews with eight groups of Year 12 students, discussing issues around three main topics: 1) subject choices, 2) careers and employment and 3) engineering as a career. The assumption underpinning these choices of topics was that there would be a relationship between all three: the students' subject preferences and choices would be shaped by, or shape occupational preferences and decisions, which in turn would affect decisions for or against engineering as a career. The interviews sought to explore qualitatively whether there was evidence that gender was somehow shaping the students' choices and attitudes in each of these three areas.

One of the main purposes of the group interviews had been to explore the hypothesis that engineering and engineering-related subject disciplines have a masculine image that discourages many girls and some boys from studying and working in these areas. An objective, therefore, was to establish to what extent the sex-stereotyping of fields of knowledge (maths and physics in particular), might be influencing the students' attitudes and choices, both in terms of sixth form study and careers. Certainly, the interviews confirmed that the subjects the participants had chosen to study in Year 12 were divided along traditional gender lines, with the girls over-represented in biology, English, history and sociology and boys over-represented in chemistry, maths and physics (see Appendix I). What became clear, however, was that the participants had not *consciously* reflected on issues of sex and gender in connection with their subject or career choices, which were understood by them to be primarily the outcome of individual personalities, preferences or abilities.

Despite the participants' tendency to 'negate the impact of gender' (Francis, 2000: 47), however, they were aware of the impact of gender, albeit not consciously, and often made use of various discourses of gender, which served to contradict the pervasive discourses of 'individuality' and 'individual opportunity'. Although unaware of it, participants themselves were active in making and re-making gender-stereotypes in relation to subject disciplines. One way in which this was evident was the way in which participants constantly reinforced binary links between the masculine/feminine dichotomy and other dichotomies, such as factual/ perceptual, short 'right or wrong' answers/essay writing, by constructing them as opposites. Consistent with Weinreich-Haste's (1989) and Thomas's (1990) theories about binary thinking and the gendering of knowledge, the following dichotomies could be 'read off' from the conversations and understandings of these students, in relation to both school subjects and occupations:

male	female
science	art
difficult	easy
academic	non-academic
facts	perceptions
logical	creative
'A-list' subjects (high status)	'B-list' subjects (low status)

This finding appears to offer support for the hypothesis that gender-stereotyping does influence the educational and occupational choices of young people, albeit not at a conscious level (Whitehead, 1996).

The section of the interview that covered issues relating to careers and employment found that engineering and teaching were the two most popular career aspirations amongst these participants, although these aspirations were divided along traditional gender lines, so that all the potential engineers were male and all the potential teachers female. Work values also differed for females and males, with female participants prioritising fulfilment, and males high earnings, as the factor they each considered most important in a future career. These work values were to be tested again later in the follow-up survey, to establish whether they were representative of a larger population of students. In line with the earlier part of the interview, the participants favoured individualist explanations and equal opportunities views when asked questions about the 'sex-appropriateness' of occupations. Also consistent with the earlier part of the interview, however, gender kept appearing in the discussions in more indirect ways. Although supporting equal opportunities, some participants also drew on biologically deterministic assumptions about the capacities and abilities of males and females. Conversely, some participants made references, albeit indirectly, to their awareness of the power of *social* stereotypes to shape the occupational choices of men and women. In relation to engineering more specifically, many participants showed that they were aware that women would have to 'prove' themselves and would only be able to succeed on men's terms, confirming that the 'masculinity' of engineering had been noted as a barrier to women.

It is worth noting that the section of the interview that focused on engineering prompted less discussion than had the earlier sections on subject and career choices and this may have been partly a reflection of the participants' general lack of interest in the topic. It was clear that there was a certain amount of confusion and a lack of knowledge about what engineering is, as well as a certain amount of indifference towards it. These would be issues that would be tested further in the follow-up survey. There was also a tendency amongst the girls in particular, to construe engineering as low status, manual work and for all participants to find the practical aspects of engineering more salient than the intellectual aspects. Again, these were issues identified for further testing in the survey. Many of the students were keen to support an equal opportunities view in relation to women's participation in engineering, although some ambivalence about women engineers was evident amongst one group of male participants. In their thinking about roles for women in engineering, some of the male participants drew on essentialist notions of sexual difference in physical strength to position women in non-strenuous forms of work. Despite their claims to know little about engineering, the majority of participants were aware that engineering is a male-dominated occupation and saw this as problematic for women in a number of ways, including the discomforts that would be posed by potential hostility, sexism, discrimination and having to reconcile a demanding career with family life. The participants' awareness of these issues did not, however, sit comfortably with their frequent tendency to 'negate the impact of gender'.

In summary, the interview findings showed that there was evidence that notions of masculinity and femininity were shaping subject and career choices and attitudes towards engineering. However, there was a tension between the participants' equality beliefs and the sex-traditional choices many of them had made for themselves. There was an inconsistency between the students' understandings of their own decisions as unrelated to gender, yet at the same time, their awareness of the way that masculinity and femininity shapes people's experiences and choices.

A further point is worth reiterating in relation to the participants' equality beliefs. It was likely that many of the students had become aware of the feminist principles of the research and for this reason may have been keen to present a 'politically correct' view in the face-to-face setting of the interview. For this reason, the focus groups may not have accurately reflected the strength of views about sex equality. It was therefore of interest to find out whether the use of anonymised self-completion questionnaires in the follow-up survey would yield similar or different results.

The strength of the focus groups was that they revealed how the students understood the issues relating to subject choice, career choice and engineering and typically talk about these topics (see Morgan, 1988). A criticism often levelled at quantitative, or 'structured' research is that it tends to be driven by the researcher's concerns (Punch, 1998: 247). Using the focus group method allowed for a compromise between my agenda and the participants' and, where possible, the frames of understanding and 'narratives' that emerged in these interviews were used to develop questionnaire items for the next stage of data collection. It was hoped that by using the focus group participants' understandings to inform the questionnaire design, this would help to make the questionnaire clearer and easier to understand for the survey respondents. In turn, the survey respondents would be more likely to understand and respond to the questionnaire, which would help to strengthen the reliability and validity of the survey.

Although the focus group participants were chosen to be as representative as possible of those who would be taking part in the larger survey, no claim to representativeness is made for the focus group data, which reflects the views of a fairly small and purposive sample of Year 12 students. However, the survey which follows was designed to assess the extent to which some of these interview findings might be representative of a larger sample of Year 12 students, and to further explore the relationships between key variables identified in the interviews. As mentioned at the outset of this chapter, the focus groups, although initially intended primarily to contribute to the development of the survey, proved to be a rich source of data in their own right. This meant that, when analysed further, they could complement the survey data by illuminating meanings which could not be captured by the questionnaire. For this reason, the focus group data will be re-visited later on in the work, when the findings from both the qualitative and the quantitative research are drawn together in the concluding Chapter of the thesis. Before this, Chapters Four and Five will present and discuss the findings from the self-completion survey.

CHAPTER FOUR:

Subject choices and intentions towards engineering

Introduction

This chapter reports part of the findings from the quantitative survey of Year 12 students, the overall aim of which was to identify the main predictors of positive intentions towards engineering careers and to establish to what extent these might differ for females and males. Chapter Two discussed the fact that the post-16 subject choice process is an important one in either leaving opportunities open to professional engineering careers, or closing them off, because particular subjects, usually mathematics and physics, are necessary for entry to undergraduate training. Girls have traditionally been less likely to choose these subjects for advanced level studies than have boys and many studies have provided evidence that this is because these disciplines are gender-stereotyped as masculine. It is not merely a matter of encouraging more girls to take up these subjects, however, as many believe that educational and occupational choices are closely linked, claiming that the gender-stereotyping of school subjects leads to a gendered dichotomy in further and higher education and in the labour-market (Weinreich-Haste, 1981 and 1986; Archer and Freedman, 1989; Lightbody and Durndell, 1998). A second focus on subject choice is driven by the argument that mathematics and the physical sciences are less popular with A-level students than in the past and that this partly accounts for the general downturn in applications to engineering degrees. The data in this chapter is concerned with the relationship between students' subject choices and their choices towards engineering. It examines students' intentions towards engineering and the association between these and their subject choices and preferences in order to test the hypotheses that the engineering-related school subjects are stereotyped as 'male' subjects and that they are generally not popular amongst the students.

The findings reported in both this chapter and the next were generated via a questionnaire survey of Year 12 students, attending LEA-maintained, coeducational comprehensive schools with sixth forms in Plymouth and Bristol. The questionnaire was distributed to the nineteen eligible schools between January and April 2000 and the final questionnaires were returned in June 2000. The questionnaire (Appendix IV) collected factual and attitudinal data on students' educational and occupational choices and their perceptions of school subjects, of engineers and of engineering as a career. The section of the questionnaire addressed in this chapter asked students which subjects they were studying in Year 12; how much they enjoy particular areas of the curriculum; which factors had been influential on their subject choices; whether there had been any constraints on their subject choices and which technology course they had studied for GCSE. This section of the questionnaire also measured students' perceptions of different subject disciplines on a number of attitude scales to assess the degree to which these disciplines can be said to be gender-stereotyped.

The Chapter begins with some discussion of the dependent and independent variables used in the analyses, before moving on to describe the characteristics of those students with positive intentions towards engineering careers. The rest of the chapter then examines students' subject choices, the factors that influenced these choices and their perceptions of subjects, with particular regard to the effects of gender and intentions towards engineering upon these choices and perceptions.

Chapter Five will present the data relating to career aspirations and attitudes towards engineering. The aims of both Chapters Four and Five are primarily descriptive. Each of the two chapters presents both univariate and bivariate analyses of the relevant data, in order to explore relationships between variables. Elaboration techniques are used on the bivariate relationships, in order to analyse and compare sub-groups of students on these variables (see Oppenheim, 1992; de Vaus, 1993). Percentages reported discursively are rounded to two decimal places.

Issues of analysis

Dependent variables

Intention towards engineering

The main dependent variable in the investigation was intention to pursue engineering as a career. This was measured by asking the students to indicate how likely they thought they were to consider a career in engineering. Those who said they were 'likely' or 'very likely' to consider engineering were classified as 'engineers' and those who said they were 'unlikely' or 'very unlikely' to consider engineering were classified as the 'non-engineers'. The 'engineers' category contained 89 students (16% of the total sample), 76 were male and 11 female (two respondents had not stated their sex). At the outset of the research, it had been hoped that any similarities and differences between males and females considering engineering could be explored. Since, however, only 11 girls in the sample said they were likely to consider an engineering career, compared with 76 males, it was not possible to make more than tentative comparisons between the responses of female and male engineers or between female engineers and other groups of students. Ideally, similarities and differences between these groups would need to be explored further in future work, perhaps by using depth interviews with both males and females who had expressed an interest in pursuing engineering as a career, or by over-sampling potential female engineers in quantitative surveys.

Science/Technology background

A second dependent variable was provided by the students' science/technology background, as defined by the subjects they were studying. Given that qualifications in science and technology subjects (mathematics and physics in particular) are a precondition of entry to many engineering courses in higher education, the students' science/technology academic background was considered an appropriate dependent variable for some analyses. Those students who have opted to study science and/or technology subjects beyond compulsory education have demonstrated a level of commitment to them, whatever their reasons might be. It was therefore of interest to explore the students' reasons for choosing science and technology and find out whether a positive orientation towards these subjects is linked to positive intentions towards engineering careers. In addition, collecting data on students' science/technology backgrounds was a useful supplement to the data on their intentions towards engineering. This is because students are only indicating whether or not they are likely to *consider* a career in engineering, whereas those who have chosen to study science and/or technology to A-level have demonstrated a commitment to these areas and in so doing, have kept an engineering career open as an option. A further weakness of the intention to pursue engineering variable is that the students may be interpreting the meaning of engineering in different ways and it is not possible to know how engineering was being conceptualised by the students when they responded to the question. To address this weakness, data on how students define engineering and how much they feel they know about it was collected elsewhere in the questionnaire. The science/technology background variable was operationalised by dividing the students into two groups according to the A-level subjects they were studying. Those students studying one or more A-levels in the sciences and/or technology subjects that are closely related to engineering (here defined as physics, mathematics, further mathematics, design/technology, computer science/studies or chemistry) were classified as 'scientists/technologists'[1]. Students not studying any of these subjects were allocated to the 'non-scientists/technologists' group. The 'scientists/technologists' category contained 164 students (38% of the A-level students), of

[1] Biology and the social sciences were excluded from the 'scientists/technologists' category, as they are not closely related to engineering and also tend to be 'quantitatively highly feminised' at secondary school level and beyond (see Glover, 2000).

whom 64% were male (105 students) and 36% female (58 students) – one student had not indicated his or her sex.

Independent variables

Since the research is concerned with explanations for the low participation of females in engineering, the main independent variable in the investigation was gender. However, gender interacts with numerous other factors to produce particular patterns of participation in engineering. Therefore, following the findings of other studies on factors influencing choices in engineering, a number of other independent variables were included in the analyses. These included socio-economic status, school location, personal contact with an engineer (Woolnough, 1994 and 1997); attitudes and choices towards school science and technology subjects (Lightbody and Durndell, 1998); sex-stereotyped perceptions of school subjects (Weinreich-Haste, 1986; Archer and Freedman, 1989; Whitehead, 1996), subject preferences (Francis, 2000), career values (Lips, 1992; Lightbody et al. 1997); levels of knowledge held about engineering (Foskett and Hemsley-Brown, 1997; MORI, 2001); perceptions held of engineers (Woolnough, 1994 and 1997) and attitudes towards engineering as a career (Foskett and Hemsley-Brown, 1997, MORI, 2001).

An implicit assumption in much of the literature is that positive attitudes and choices towards science and technology are related to positive choices in engineering. To test this hypothesis, in addition to being one of the dependent variables, science/technology background also served as one of the key *independent* variables in the investigation. Most students are not taught engineering in any direct manner in schools, whereas some science and technology are compulsory for all pupils to the age of 16 and provide the initial experience and knowledge-base required for later specialisation in engineering. Experiences and perceptions of school science might therefore be expected to have a bearing on attitudes and intentions towards engineering. It was assumed at the outset of the research, for example, that those students who had chosen to study mathematics, the physical sciences or technology might be more positively orientated towards engineering than those who had not chosen these subjects.

Characteristics of respondents

Respondents were 606 Year 12 students, 320 female and 278 male (in eight cases the sex of the respondent was not made clear). A binomial test showed that the number of males and females did not differ significantly from the binomial assumption of equal probability of either (George and Mallery, 2001: 201). The students were aged 16 or 17 years of age. Approximately three-quarters (77%) of the students were attending schools in Plymouth and approximately one-quarter (23%) were attending schools in Bristol. The vast majority of students were following A-level courses, GNVQ courses, or a combination of both A-level and GNVQ.

Students were allocated to one of three social class groups (see Table 7 below), derived from information about the occupational status of their parents or guardians (see Chapter Two for a full explanation). The class distribution for students as a whole was bimodal, with just over half (52%) of the students in Class 1 (Managerial and Professional), only 15% in Class 2 (Intermediate), and 33% in Class 3 (Working). The reasons for this distribution were not entirely clear, but given the relationship between socio-economic status and educational achievement, it would be expected that students continuing in post-compulsory education would be more likely to be in Class 1 than in Class 3. There were no differences between males and females in their distributions in the three class groups.

Intentions to pursue engineering as a career

This section of the chapter presents the findings relating to respondents' intentions towards engineering careers. It will firstly describe the proportions of respondents who said they were likely to consider a career in engineering. It will then elaborate on the association between intentions towards engineering careers and a number of other 'attribute' variables, namely gender, social class, science/technology background, school location and connections with engineers.

Proportion of students considering a career in engineering

Of the total sample, (n=606), 89 respondents (16%), said they were 'likely' or 'very likely' to consider a career in engineering. The percentage of respondents expressing an interest in engineering was higher than expected, given that students accepted to engineering degree courses in 1999 were less than 6 per cent of the total cohort of accepted applicants (Engineering Council, 2000). This high percentage may be partly explained by 'social desirability' bias (see Oppenheim, 1992: 181), or the fact that those students interested in engineering had been more inclined to complete the questionnaire. It should also be noted that these are respondents who report that they are likely to *consider* engineering, rather than those who have made it a firm career plan. The proportion of students actually stating engineering as a definite career choice was much smaller than those who said they would *consider* it, at only 6 per cent of those with career plans (n= 403). This has been found elsewhere. In his study Winter (1992) also found that the ratio between the percentage of respondents prepared to consider engineering and those actually intending it as a career differed, with only a quarter of those considering it actually going into it (Winter, 1992: 12). It is difficult to assess the true level of interest in engineering amongst this sample. However, a number of other scientific and technological occupations were stated by those respondents with career aspirations, including 'computer-related work', 'architecture/construction' and 'science-based work', indicating a wider level of interest in occupations possibly related to engineering (see Chapter Five for data on students' career aspirations).

Intentions to pursue engineering by gender

As mentioned earlier, gender was the key analytical variable in this study. The data on students' intentions towards engineering revealed that, as expected, males were much more likely than females to say they were likely to consider a career in engineering (30% of males, compared with only 4% of females). Seventy-six of the students in the 'engineers' category were male (87%) and only eleven were female (13%), making males in the sample nearly seven times more likely than females to consider it (note: two of the respondents considering engineering had not stated their sex). The difference between males and females in their intentions to pursue engineering was found to be a significant one (Chi-square statistic = 73.308, df = 1, p=0.000).

Intention to pursue engineering by social class

Analyses of sub-groups on the social class variable revealed that those students who were likely to pursue engineering were more likely to have parents in Class 1 than students as a whole. The differences between the 'engineers' and the 'non-engineers' on the class variable was significant (Chi square statistic = 6.666, df = 2 p = 0.036). However, the 'scientists/technologists' were the group most likely to have parents in Class 1 and least likely to have parents in Class 3. The class distributions for all students and for the sub-groups 'engineers' and 'scientists/technologists' are shown in table 7 below.

Table 7: Students by parents' occupational status

	% All students (n=496)	% Engineers (n=74)	% Scientists/ Technologists (n=135)
Class 1: Managerial & Professional	52.4	60.8	63.0
Class 2: Intermediate	14.5	5.4	10.4
Class 3: Working	33.1	33.8	26.7
	100.0	100.0	100.0
	missing = 110	*missing = 15*	*missing = 29*

Although for the sample as a whole, there were no differences between females and males in their distributions in each of the class groups, elaborations on these variables controlling for gender, revealed that females considering engineering and females studying science or technology subjects were more likely to be in Class 1 than males in both of these groups. Within the 'engineers' group, more than three-quarters (78%) of the females likely to consider engineering had a parent in Class 1, compared with just over half (58%) of the males. However these differences are not necessarily representative, due to the small number of females in the sample who said they were likely to consider engineering as a career. Within the 'scientists/technologists' group, 73% of females and 58% of males had a parent in Class 1, although again, these differences were not significant.

Intentions to pursue engineering by science/technology background

The 'scientists/technologists' category, outlined earlier in the chapter, contained 164 students, this was 27% of the sample as a whole, and 38% of all A-level students. Within this category, 64% were male (105 students) and 36% female (58 students). It had been hypothesised that these students, who had chosen to study mathematics, the physical sciences or technology subjects, might be more positively orientated towards engineering than those who had not chosen these subjects. Cross-tabulations of students' intentions towards engineering by the various subjects they were studying showed that this was indeed the case. Only 16% of all students in the overall sample had said they would consider engineering, whereas 32% of the 'scientists/technologists' did. To further explore this relationship, the science/technology background variable was crosstabulated with intention to pursue engineering as a career. The difference between the 'scientists/technologists' and 'non-scientists/technologists' in their intentions towards engineering was found to be significant (Chi-square statistic = 39.225, df = 1, p = 0.000).

Within the various science and technology subjects, those studying physics were the most likely to say they would consider engineering, with 62% of those studying physics saying yes, followed by technology (58% of students), further mathematics (50%) design (48%), mathematics (33%), computer science (31%), and finally, chemistry, the least likely, with 22% of the students studying it saying they would consider an engineering career. These findings tend to offer support for the view that students interested in the physical sciences and technology are more likely to be interested in engineering careers than those not studying these subjects.

Intentions to pursue engineering by school location

It was also of interest to find out whether the geographical location in which the students' lived had an influence on their aspirations towards an engineering career. At the outset of the study, it had been hypothesised that students in Bristol would be more likely to pursue engineering careers than would students in Plymouth, because of the arguably more visible presence of engineering employment opportunities in Bristol, such as British Aerospace. There were, however, no significant differences between students in Plymouth and Bristol in their intentions towards engineering careers. Crosstabulations controlling for gender, however, revealed that females likely to consider engineering were more highly-represented in the Bristol schools than in the Plymouth schools. In Bristol schools, females constituted 26% of all 'engineers', whereas in the Plymouth schools, females were only 9% of all 'engineers'.

Male 'engineers' were represented in all ten of the Plymouth schools, with more than half of these concentrated in just three schools. In Bristol, male 'engineers' were represented in five of the six schools and just under half of these attended the same school. The eleven female 'engineers' were students in three of the Plymouth schools and four of the Bristol schools. They were divided fairly equally between schools in the two cities, with six attending Plymouth schools and five attending Bristol schools. Four of the six female students from Plymouth were attending the same school and two of the five in Bristol were attending the same school.

Intention to pursue engineering by connections with an engineer

Having personal connections with an engineer, either a relative or close friend, was another independent variable in the investigation. This is because previous studies into the career decision-making of engineering students have found that having a close relative in engineering is an influential factor in their choice to take up engineering themselves (Woolnough, 1994; Woolnough, et al., 1997; Foskett and Hemsley-Brown, 1997). This hypothesis was operationalised by asking respondents whether they have a relative or close friend in engineering and, if so, to state the nature of the relationship.

More than one third (36%) of all respondents (n=606) reported having personal connections with an engineer. Table 8 below shows a breakdown of the specific nature of the relationships of the engineers to the respondents. It can be seen from the table that just over half of those respondents reporting a connection to an engineer had a father in engineering.

Table 8: Nature of relationships of engineers to respondents

Engineer	frequency	%
father	110	50.5
other male relative	59	27.1
male friend	41	18.8
female relative	2	0.9
female friend	2	0.9
insufficient information	4	1.8
Totals	218	100.0%

A crosstabulation of the 'connection with an engineer' variable with the intention to pursue engineering variable revealed, as expected, that having personal contact with an engineer was a positive influence on respondents' intentions to pursue a career in engineering themselves. 23% of students who reported a connection with an engineer were likely to consider a career in engineering themselves, compared with only 11% of those who had no connection with an engineer (Chi-square statistic = 13.157, df = 1, p = <0.0001). Fathers appeared to be particularly influential on the students' aspirations. The 'engineers' were almost twice as likely to have a father who is an engineer as the 'non-engineers' (29% and 16% respectively). This connection appears to be even more important for females than it is for males. Almost half of the female 'engineers' had a father who is an engineer, compared with just over one-quarter of the male 'engineers'. When other male relatives are included in the analysis in addition to fathers, this pattern persists. Approaching one half of the 'engineers' had a father or other male relative who is an engineer (46%), compared with only one-quarter of the 'non-engineers' (25%). Again, this connection appears to be stronger for females. Almost two-thirds of the female 'engineers' had a father or other relative in engineering, compared with only two-fifths of the male 'engineers'.

Summary: Intention to pursue engineering

The wider pattern of low female aspiration towards engineering careers was replicated in the career intentions of the young women in this study. Clearly gender is an important predictor of intentions towards engineering. A sizeable proportion of males – almost two-thirds of all males in the sample (30%), had said they were 'fairly likely' or 'very likely' to consider a career in engineering, compared with only a tiny minority of females (4% of all females in the sample). Engineering is therefore popular with boys as a career they will *consider*, if not actually aspire to. There was evidence to suggest that having connections with an engineer is a positive influence on respondents' aspirations towards engineering.

This seemed to be even more important for girls than for boys, with higher proportions of female 'engineers' than male 'engineers' reporting they had a relative who is an engineer. Geographical location was not found to be a significant factor in aspirations towards engineering for respondents as a whole, however girls in the Bristol schools were much more likely than girls in the Plymouth schools to say they would consider engineering as a career. Claims about differences between male and female 'engineers' can only be tentative, however, as the number of female 'engineers' was very small.

Subjects studied

This section of the chapter presents information on the types and range of subjects chosen by the respondents for their Year 12 studies. This information was collected to examine the extent to which subject choices might be differentiated by gender and to assess the proposition that those subjects required for entry to engineering degrees, namely mathematics and, to a lesser extent, physics, are not popular amongst students. Subject choices are therefore analysed by gender and intentions towards engineering.

Types of qualifications studied

A-levels were the most commonly studied type of qualification in the sample. Almost three-quarters (72%) of the sample as a whole (n=606) were studying one or more A-level subjects and 76% of 'engineers' were studying them. Of those students who were studying A-levels, GNVQs or a combination of the two (n= 562), the majority of these (69%) were taking A-levels alone. A small proportion (8%) of the A-level students were combining these with an AS subject (see section on AS qualifications below). The second largest proportion of the students (22%), were studying GNVQ subjects only and 9% of students were combining A-level and GNVQ subjects. A very small number of students were taking subjects other than A-level, AS level or GNVQ (re-takes of GCSEs for example) and did not fall into any of the above groups.

There were no significant differences between the proportions of males and females studying A-levels, AS levels and GNVQs. Nor were there any differences between the proportions of 'engineers' and non-engineers' studying these types of subjects, showing that, in this sample, potential engineers are no more or less likely to study either vocational or academic subjects than other students. 'Scientists/technologists', however, different from the other groups in that they were significantly more likely to be studying A-levels *exclusively* than were 'non-scientists/technologists', with only 4% of the 'scientists/technologists' combining both A-levels and GNVQs, compared with 17% of the 'non-scientists/technologists' (Chi-square statistic = 17.006, df = 1, p = 0.000). This indicates a trend towards the more 'academic' and less 'vocational' subjects amongst the scientists/technologists group. Controlling for social class revealed some differences between the groups in the types of subjects studied. Students in Classes 1 and 2 were more likely than those in Class 3 to be studying A-levels only, whereas students in Class 3 were more likely than the other two groups to be studying GNVQ only (Chi-square statistic = 16.727, df = 4, p = 0.002).

A-level subjects

A total of thirty-three different A-level subjects were being studied within the sample. English was the most commonly studied A-level subject (32% of those taking A-levels), with general studies in second place (26%) and mathematics in third place (25%). All of the students studying general studies attended schools in the Plymouth area. The high numbers of students in the sample taking general studies was unsurprising, given that many Plymouth schools enter their Year 12 students for this subject as a matter of course.

As expected, the sex of the student had an influence on the subjects the students had chosen to study. Males were over-represented in mathematics, physics, business studies, design, technology, economics, information technology, graphics, further maths and geology. Females were over-represented in English, biology, sociology, drama, psychology, French, Spanish, German, home economics, textiles, religious studies, law, music and politics. The most gender-stereotyped subjects according to these choices (of those subjects containing more than ten respondents), are home economics (93% females) and computer studies (93% males). Several subjects however, can be termed 'gender neutral', in that roughly equal proportions of males and females are studying them. These are the following subjects, which contain no more than 60 per cent of either sex: general studies, art, history, geography, chemistry, sports studies, P.E. and media.

Table 9 below shows the percentages of each sex within each of the A-level subjects, revealing a gender dichotomy in A-level subject choice which mirrors the pattern found in previous studies (Stables and Stables, 1995; Lightbody and Durndell, 1996; Whitehead, 1996) and in current DfES statistics on A-level entries for young people in England (see for example, DfES 2001 and 2002).

Table 9: A level subjects studied, by gender

Subject	Males as a % studying subject	Females as a % studying subject	Totals studying each subject
English	30.1	69.9	136
Maths	63.2	36.8	106
General Studies	49.6	50.4	113
Art	40	60	80
Biology	39.2	60.8	79
Sociology	32.1	67.9	78
History	43.5	56.5	69
Geography	49.2	50.8	59
Physics	86.5	13.5	52
Drama	37.5	62.5	48
Psychology	23.4	76.6	47

Table 9 (continued): A level subjects studied, by gender

Subject	Males as a % studying subject	Females as a % studying subject	Totals studying each subject
Business Studies	63.8	36.2	47
Chemistry	55.0	45.0	40
Sports Studies	59.4	40.6	32
Media	56.7	43.3	30
Design	74.1	25.9	27
French	26.1	73.9	23
Technology	81.8	18.2	22
Spanish	26.3	73.7	19
German	33.3	66.7	18
Economics	71.4	28.6	14
Computer studies	92.9	7.1	14
Home Economics	7.1	92.9	14
Information Technology	81.8	18.2	11
Textiles	11.1	88.9	9
Graphics	83.3	16.7	6
Religious studies	16.7	83.3	6
Law	33.3	66.7	6
Music	33.3	66.7	6
PE	60.0	40.0	5
Politics	33.3	66.7	3
Further Maths	100.0	0	2
Geology	100.0	0	1

AS-level subjects

The data reported here was collected prior to the implementation of the broader curriculum (*Curriculum 2000*), introduced in England and Wales in September 2000. At this time, AS-level qualifications were not widely studied[2]. Therefore only a very small proportion of the sample as a whole (6%) were studying an AS-level, usually in combination with A-levels (only two respondents were taking two AS-levels, both of whom were 'engineers'). The most frequently studied AS-level subject was Further Maths, taken by 32% of those studying AS-levels. More than half of those studying Further Maths AS-level were 'engineers' and, by definition, all were 'scientists/technologists'.

[2] At this time, AS levels were half an A-level, taken over two years. Now they are year one of the full A-level course.

GNVQ subjects[3]

Almost a third (30%) of students in the sample as a whole were studying one GNVQ subject[4]. Almost three-quarters (71%) of those taking a GNVQ were not studying any A-levels, 24% were combining a GNVQ with one A level, and just 4% were combining a GNVQ with two A levels. Table 10 below shows the percentages of males and females in the various GNVQ subjects. As with the A-levels, a gender dichotomy in the types of GNVQ subjects studied was evident. Business Studies is the only subject that is gender-neutral, studied in roughly equal proportions by males and females (44% and 56% respectively). Of the other two most popular subjects, Health and Social Care is overwhelmingly female-dominated (96% females), whereas Leisure and Tourism/Recreation is male dominated (61% males).

Table 10: GNVQ subjects studied, by gender

	Males as a % studying subject	Females as a % studying subject	Total studying subject
Business/Business & Finance/ Business & Admin	43.9	56.1	57
Health and Social Care	4.3	95.7	47
Leisure & Tourism/Recreation	61.3	38.7	31
Information Technology	89.5	10.5	19
Art and Design	66.7	33.3	15
Performing Arts & Entertainment	25.0	75.0	4
Engineering	100.0	0	3
Science	100.0	0	1

A slightly lower proportion of the 'engineers' (26%) was studying a GNVQ subject than respondents as a whole (30%). Surprisingly, almost a third of the 'engineers' studying a GNVQ were studying Leisure and Tourism, as opposed to engineering-related subjects. Only three of the 'engineers', all male and studying at the same Plymouth school, were studying GNVQ Engineering.

[3] GNVQ have since been replaced by AVCE (Advanced Vocational Certificate of Education)

Engineering-related A-level subjects

Mathematics and physics are the A-level subjects most attractive to admission tutors of engineering courses in higher education (Engineering Council, 2002). Mathematics is the more important of the two subjects, being essential for entry to a wide variety of degree-level courses in engineering. However, reports about the declining numbers of students taking A-level mathematics, coupled with declining student applicants to engineering courses, has given rise to debate within the engineering profession as to whether mathematics A-level should continue to be essential for some engineering disciplines (see, for example, Hansford, 2003). It was therefore of interest to note how popular mathematics and physics were amongst this sample of students. Not counting general studies, mathematics was the second most widely studied A-level subject, with a quarter of the A-level students studying it, indicating that it is still a very popular choice with students for advanced study, if not necessarily *liked*. Physics was rather less popular, studied by only 12% of the A-level students, although still amongst the 'top ten' subjects studied.

As expected, females were under-represented in all the engineering-related A-level subjects. Even though mathematics was a popular subject choice generally, it was much more likely to be studied by males, who were almost two thirds of the students taking it. Thirty four per cent of the male A-level students had chosen to study mathematics, compared with only 17% of the female A-level students (Chi-square = 15.763, df = 1, p = 0.000). With physics, the gap between the sexes was even greater, with 23% of the male A-level students studying it, compared with only 3% of the females (Chi-square = 38.094, df = 1, p = 0.000). Given that some Bachelor of Engineering (BEng) admissions tutors like applicants to have qualifications in both mathematics *and* physics, it was of interest to see

[4] The majority of those students taking GNVQ were studying one subject only. Only two respondents were studying two GNVQs.

what proportion of the A-level students were studying both of these subjects, and could therefore be 'potential' BEng students. Use of the 'select cases' facility in SPSS showed that this proportion was small, with only 40 students (9% of the A-level students and 7% of students as a whole) were studying both of these subjects. Furthermore, the overwhelming majority of these (37) were male.

Table 11 below compares the percentage of all A-level students studying the various engineering-related A-levels with the percentages of 'engineers' studying them.

Table 11: Percentages of all students and 'engineers' studying various engineering-related A-level subjects

A-level Subject	% All A-level students (n=437)	% Engineers (n=68)
Maths	24.5	47.1
Further Maths	0.5	1.5
Physics	11.9	42.6
Design*	6.2	16.2
Technology*	5.0	16.2
Computer studies	3.2	5.9
Chemistry	9.2	11.8

Note: It is probable that Technology and Design are different terms for the same course (Design and Technology). It is not possible, however, to know which subject was followed *within* the course.

The table shows that although mathematics A-level was more popular with the 'engineers' than with students in general, nonetheless less than one-half (47%) of all the 'engineers' were studying it. This is a low proportion, given that A-level mathematics is essential for entry to most engineering degree courses. Within the 'engineers' category, the females were even less likely to be studying mathematics than the males. Just over one-quarter (27%) of the eleven female engineers were taking mathematics A-level (three girls), compared with 38% of the male engineers. Less than one-half (43%) of all the engineers were taking physics A-level. Again however, less than one fifth of the female engineers were taking physics A-level (two out of eleven girls), compared with just over one-third (36%) of the males. A larger proportion of the 'engineers' (27%) than of students in general (9%) were studying both maths *and* physics at A-level (twenty-four students). However, only one of these students was female.

Summary: Subjects studied

The students' subject choices reflected traditional patterns of gender differentiation, with boys over-represented in the physical sciences and technology and girls over-represented in the arts, the humanities and the social sciences. Despite arguments about the declining popularity of mathematics, it was the second most frequently studied A-level subject in this sample of students, although the majority studying it were male (63%). Physics was rather less popular than mathematics, but it was nonetheless amongst the top ten most frequently studied subjects and has always been studied by a fairly low proportion of students. In common with mathematics, the vast majority of those who had chosen to study physics were male (87%).

Students in the 'engineers' category were, as expected, more likely than students in general to be studying the engineering-related A-level subjects, particularly mathematics, physics, design and technology. This suggests that positive attitudes towards the physical sciences and technology are associated with positive orientations towards engineering careers. However, if mathematics A-level and/or AGNVQ engineering are taken to be the minimum essential requirements for entry to BEng courses, less than half of the students in the 'engineers' category would be appropriately qualified to pursue engineering at this level immediately after leaving school. Furthermore, a high proportion of the students in the 'engineers' category were neither studying A-levels, nor other types of qualifications in engineering related subjects. This could indicate a number of possibilities. First, the students may have been considering entering engineering via a sub-degree route. Second, their understanding of 'engineering' may have encompassed a broad range of possible technology careers and courses, which do not necessarily require specific subjects for entry. Third, they may have been unaware of the qualifications needed to pursue many routes into engineering, or fourth, they may not have been particularly serious about considering engineering.

The vast majority of those students who were studying the appropriate advanced level qualifications to enter BEng courses were male, illustrating the fact that by the age of 17, girls' opportunities to pursue engineering careers are considerably lower than those of boys. The tendency for girls to drop out of the engineering 'pipeline' early, by virtue of their post-16 subject choices, was reflected in the subject choices of the girls in this sample of students.

Factors influencing subject choices

This section of the chapter explores the students' reasons for their subject choices and analyses these by gender, intentions towards engineering and science background to find out whether there are different factors shaping the choices of different groups of students. Data was collected on a) the degree of influence school and family had on the students' subject choices and b) the students' self-reported, or 'subjective' reasons for subject choices, in order to find out whether factors influencing students' subject choices vary by gender, intentions towards engineering and science-technology background. More specifically, the data on school and family influences was collected to test the hypothesis that students considering engineering may be more influenced by parents or relatives who might be engineering 'role models', than other students. The data on subjective reasons for choices was collected to test the hypothesis that those students considering engineering may have different motivations, likes and dislikes from other students, which could influence the subject choices they made.

School and family influences on subject choices

In this section of the questionnaire, respondents were presented with a list of nine possible influences on their subject choices, which had been derived from the focus group data. They were asked to indicate how influential each of the factors had been on a four-point scale from 'not at all influential', to 'very influential' (see Table 12 below). For students as a whole, it was found that parents had been the most influential on subject choices, with 85.4 per cent of respondents saying their parents had had some degree of influence - 18.3 per cent saying they had been 'very influential' (see table 12 below). Parental influence was closely followed by that of careers teachers/advisers, who had some degree of influence on the choices of 80.5% of respondents and other teachers (influential on 80.8% of respondents). Next most influential were friends (influential on 76% of respondents), and school talks/visits (influential on 68.7% of respondents). Much less influential were the media (44.6%), siblings (36.5%) and other relatives (41.3%), with libraries the least influential of all (only influential on 34.3% of respondents). A small percentage of respondents (14.6%) said that 'other' factors had influenced their subject choices, although these were not stated.

Table 12: School and family factors influencing subject choice in Year 12 – All respondents

	% Very Influential	% Influential	% Slightly Influential	% Not at all Influential	Totals
Parents	18.3	32.1	35.0	14.6	100.0 (n=602)
Careers Adviser/teacher	14.5	39.7	26.3	19.5	100.0 (n=600)
Other teacher	13.1	36.4	31.3	19.2	100.0 (n=594)
Friends	10.2	31.7	34.2	24.0	100.0 (n=597)
School talks/visits	8.9	24.9	34.8	31.3	100.0 (n=594)
Media	4.9	13.6	26.1	55.4	100.0 (n=587)
Siblings	4.7	12.0	19.8	63.5	100.0 (n=591)
Other relatives	3.7	13.8	23.8	58.7	100.0 (n=596)
Libraries	1.2	9.8	23.3	65.7	100.0 (n=592)

The original four-category variable was then re-coded into two categories, 'influential' and 'not influential' and the sub-groups of students were compared using crosstabulations and analysis of Chi-square. An analysis of Chi-square statistics indicated that there were no significant differences between the influences on males' and females' subject choices on six of the nine factors. However, the sexes differed on three of the factors. Both parents and careers teachers were more influential on girls' choices than those of boys, whereas the media had been more influential on the choices of boys than those of girls (all three factors were significant below the 0.05 level of probability).

It had been hypothesised at the outset that those choosing engineering as a career would be more likely to have parents who were engineers. However, when the responses of the 'engineers' and the 'non-engineers' were compared, there were no significant differences between the two groups on all nine factors. Within the 'engineers' group, males and females were also compared and there were no marked differences between them on six of the nine factors, but three of the factors appeared to be more influential on the subject choices of male engineers than on those of female engineers. These were: relatives other than parents, school talks/visits and use of libraries. Significance testing was not possible however, due to the small number of female engineers.

There were no significant differences between the 'scientists/technologists' and the 'non-scientists/technologists' on all nine factors. Within the 'scientists/technologists' category, males and females were compared and there were no differences between them on seven of the nine factors. However, both media and siblings were found to be more influential on the subject choices of male 'scientists/technologists' than of female 'scientists/technologists' (both significant below the 0.05 level of probability).

Gender would appear to explain most of the differences between the sub-groups of students. In each case, girls were more likely to say that significant others (for example, their parents or teachers) had influenced them in their choices, whereas boys were more likely to attribute their choices to a set of wider factors, such as library and media resources.

Subjective reasons for subject choices

During the preceding focus group interviews, participants had also been asked why they had chosen the particular subjects they were studying in year 12. The responses the students gave in these interviews were then used as the basis for a questionnaire item in the follow-up survey. A list of the eleven most frequent reasons given in the interviews was presented to survey respondents in the form of statements which they were asked to agree or disagree with along a four point scale where 1 = disagree strongly and 4 = agree strongly. Table 13 shows the percentages of all respondents who agreed or agreed strongly with each statement. The three most popular reasons for choosing subjects was that they were interesting (97% agreed), that respondents would have a chance of passing them (91% agreed) and that the subjects were necessary for the respondents' intended career (79% agreed). These findings support those of other studies on subject choice (see for example, Garratt, 1985).

The majority of respondents agreed with all of the statements with the exception of two. These were 'I thought other subjects would be too difficult' (only 23% of respondents agreed) and 'I wanted to avoid subjects requiring a lot of written work' (only 18% of respondents agreed).

Table 13: Students' reasons for choice of subjects to study in Year 12. Percentages either agreeing or agreeing strongly. All respondents

Reason	%
I thought these subjects would be interesting	96.7
I thought I would have a chance of passing these subjects	91.1
I need these subjects for my intended career	78.8
I did well in these subjects at GCSE	76.0
I enjoy subjects where you can explore ideas and theories	75.5
I like subjects where you learn about people	67.7
I wanted to do subjects which have a high status with universities and employers	67.5
I enjoy subjects which involve practical, 'hands on' activities	67.1
I like fact-based subjects	62.5
I thought other subjects would be too difficult	23.4
I wanted to avoid subjects requiring a lot of written work	18.0

Cross-tabulation and Chi-square analyses were performed to examine any differences or similarities between males and females, 'engineers' and 'non-engineers' and 'scientists/technologists' and 'non-scientists/technologists' in their reasons for their subject choices. Due to the small number of frequencies in some cells, the original four category variables were re-coded into two categories, 'agree' and 'disagree'. An analysis of Chi-square statistics indicated that there were significant differences in agreement between males and females on five of the eleven statements (Table 14). Males were twice as likely as females to avoid choosing subjects requiring a lot of written work, providing support for the theory that boys have more negative attitudes towards writing and reading than girls (Clark, 1998: 37). Males were also more likely than females to choose subjects with a high status and to enjoy practical 'hands on' subjects. In contrast, females were slightly more likely than males to choose to subjects they thought would be more interesting and much more likely to choose subjects that would allow them to learn about people (all were significant at the 0.01 level of probability or below).

Table 14: Percentages of males and females agreeing with the statements

	Males	Females	Chi-square
avoided subjects involving written work	24.4	11.9	p=<0.0001
chose subjects with high status	75.7	60.2	p=<0.0001
like practical, 'hands on' subjects	73.6	60.9	p=0.001
thought these subjects interesting	94.6	98.4	p=0.01
like subjects about people	57.0	76.8	p=<0.0001

'Engineers' and 'non-engineers' differed significantly on five of the eleven statements (Table 15). 'Engineers' were more likely than non-engineers to agree they wanted to avoid subjects involving written work, that they had chosen subjects they believe have a high status with universities and employers, that they enjoy subjects that involve exploring ideas and theories, and that they enjoy subjects that involve practical, 'hands on' activities. 'Non-engineers' were more likely than engineers to say they chose subjects that allow them to learn about people (all were significant below the 0.05 level of probability).

Table 15: Percentages of 'engineers' and 'non-engineers' agreeing with the statements

	'Engineers'	'Non-engineers'	Chi-square
avoided subjects involving written work	27.3	15.6	p=<0.01
chose subjects with high status	80.9	64.4	p=<0.01
like exploring ideas and theories	84.1	73.3	p=<0.05
like practical, 'hands on' subjects	83.1	63.3	p=<0.0001
like subjects about people	50.6	71.8	p=<0.0001

'Scientists/technologists' and 'non-scientists/technologists' differed significantly on eight of the eleven statements (Table 16). In common with the 'engineers', the 'scientists/technologists' were more likely than 'non-scientists/technologists' to agree they wanted to avoid subjects involving written work; that they had chosen subjects they believe have a high status with universities and employers; that they enjoy subjects that involve practical 'hands on' activities. 'Scientists/technologists' were also more likely than 'non-scientists/technologists' to say that they like fact-based subjects; that they need these subjects for their intended career and that they did well in their chosen subjects at GCSE. 'Non-scientists/technologists' were more likely than the 'scientists/technologists' to say that they like subjects where they learn about people and that they thought other subjects would be too difficult (all were significant at or below the 0.01 level of probability). These latter differences indicate that the 'non-scientists/technologists' were the group with least confidence in their abilities, an attribute also more commonly found in females than in males (Walkerdine, 1989; Trankina, 1993; Erwin and Maurutto, 1998).

Table 16: Percentages of 'scientists/technologists' and 'non-scientists/technologists' agreeing with the statements

	Scientists/ Technologists	Non-scientists/ Technologists	Chi-square
avoided subjects involving written work	24.8	8.1	p=<0.0001
chose subjects with high status	82.3	63.0	p=<0.0001
like practical, 'hands on' subjects	74.4	56.8	p=<0.0001
like subjects about people	37.8	79.9	p=<0.0001
like fact-based subjects	71.8	58.1	p=<0.01
need subjects for intended career	82.9	72.6	p=<0.05
did well in these subjects at GCSE	96.3	81.3	p=<0.0001
found other subjects too difficult	15.9	26.8	p=<0.01

Summary: Influences on subject choices

This part of the chapter has explored the influences of school factors and family members on respondents' subject choices as well as examining their subjective reasons for these choices. These influences were also analysed by gender, intention towards engineering and science background.

As far as school and family factors were concerned, when presented with a list of possible factors, parents and careers teachers/advisers were found to be the most influential on choices for respondents as a whole. However, both these factors were significantly more influential on girls' choices than those of boys, who were more likely than girls to attribute their subject choices to a wider set of factors, including the media. No significant differences were found between the 'engineers' and 'non-engineers', or between the 'scientists/technologists' and 'non-scientists/technologists' on the factors.

In terms of respondents' subjective reasons for their subject choices, a considerable amount of overlap was found between the 'engineers' and the 'scientists/technologists' in their motivations to choose particular subjects. Both the 'engineers' and the 'scientists/technologists' agreed that they tended to avoid subjects involving written work, chose subjects they believed have a high status, and liked subjects that are practical and 'hands on'. These were also significantly more likely to be positions taken up by male students than by female students. In contrast, 'non-engineers', 'non scientists/technologists' and females tended to share an inclination towards subjects 'about people', which would be likely to include subjects such as history, English, geography, sociology and psychology, mainly those subjects traditionally chosen by girls.

Subject enjoyment

The previous section of the chapter found evidence to suggest that students with positive intentions towards engineering careers tended to be attracted towards subjects that are practical and 'hands on' and away from subjects involving written work. The 'engineers' were also less likely than the 'non-engineers' to be attracted towards subjects about people.

These attitudes were also found to be more typical of males than of females. This next portion of data further explores the relationship between intentions towards engineering careers and enjoyment of particular areas of the educational curriculum to find out whether students who are positively orientated towards engineering have particular subject 'likes' and 'dislikes' in common.

One reason for doing this is that previous studies have focused on stereotypes of the 'scientific psyche' or 'the typical engineer', investigating whether people who choose engineering as a career share certain characteristics, or personality types in common (see Newton, 1987; Woolnough, 1994, Woolnough et. al., 1997). For example, some studies have suggested that scientists (and, by extension, engineers) are commonly perceived as 'asocial' (Lips, 1992) and that this discourages many young people, especially girls, who prefer 'people' jobs (Lightbody et al. 1994), from pursuing engineering as a career. This part of the investigation set out to find out if respondents considering a career in engineering share a liking for particular areas of the curriculum and a dislike of other areas and if their subject enjoyment differs from those respondents not considering engineering as a career. In accordance with these theories, it was hypothesised that those respondents considering engineering as a career would be more likely to enjoy technology, science and mathematics and less likely to enjoy writing, learning languages and people-orientated activities than those not considering a career in engineering.

The hypothesis was operationalised by using sixteen statements relating to subject enjoyment (see tables 17 and 18 below). Respondents were asked to indicate how well each of these statements described them, choosing from the three answer options: 'yes, I am like this', 'no, I am not like this' or 'I'm not sure'. Frequency tables were produced for all students and crosstabulations of each of the statements by sex. Table 18 shows the percentages of respondents answering the 'yes' and 'not sure' categories – both for all respondents and for males and females separately.

The table reveals that around three quarters of the respondents as a whole said they enjoy being creative (76%), being imaginative (76%), using computers (75%), finding out about people (74%) and practical tasks (74%). About two thirds enjoy taking part in group discussions and debates (65%), doing sport (65%) and are career minded (61%), whilst just over half (52%) enjoy writing. Less popular with the students as a whole were theories and abstract thinking (42%), science (41%) and technology subjects (41%), with less than half the students reporting that they enjoy these. Less popular still, with only around one-third of the students enjoying them are problem-solving tasks in maths, science or technology (36%), maths (32%), and environmental issues (30%). Least popular of all was learning another language, enjoyed by only just over one-quarter of students (28%). Respondents were least certain about their feelings towards theories/abstract thinking and environmental issues, approximately one-third saying they were 'not sure' about each of these.

An analysis of Chi-square statistics indicated that there were no significant differences between the attitudes of males and females on three of the sixteen statements. These were: being career-minded, being imaginative and enjoying taking part in discussions and debates. However, males and females differed significantly in their attitudes to the remaining thirteen statements. Males were more likely than females to say they enjoy technology subjects, being creative, theories and abstract thinking, practical tasks, maths, using computers, problem-solving tasks in maths, science or technology, science and sport (all were significant at the 0.05 level or below). Females were more likely than males to enjoy finding out about people, be interested in environmental issues, like learning another language and enjoy writing (all significant at less than 0.001). On the whole, females expressed more ambivalence towards the statement than did males, being more likely than males to answer 'not sure'. The exceptions to this were: finding out about people, being career minded and learning another language (which the majority of females enjoyed) and science and maths (which the majority of females did not enjoy).

Table 17: Attitudes towards various subjects and activities. Percentages

How well do the following statements describe you?	Totals	% Yes	% Not sure
I enjoy being creative			
all	n=604	76.2	15.1
males	278	82.0	11.2
females	318	70.4	18.9
Chi-square = 10.887, df = 2, p = 0.004			
I enjoy tasks which require me to be imaginative			
all	n=603	76.0	14.4
males	278	77.3	12.6
females	317	74.1	16.4
Chi-square = 1.731, df = 2, p = 0.421			
I enjoy using computers			
all	n=602	74.6	12.0
males	276	83.7	7.6
females	319	67.1	15.7
Chi-square = 21.665, df = 2, p = 0.000			
I enjoy finding out about people			
all	n=603	74.3	15.1
males	276	60.5	22.1
females	319	85.6	9.4
Chi-square = 49.246, df = 2, p = 0.000			
I enjoy practical tasks			
all	n=601	73.7	14.5
males	277	81.9	9.0
females	316	66.5	19.0
Chi-square = 18.801, df = 2, p = 0.000			
I like taking part in discussions and debates			
all	n=604	65.2	16.6
males	277	65.7	14.1
females	319	64.6	18.8
Chi-square = 3.077, df = 2, p = 0.215			
I enjoy doing sport			
all	n=606	64.7	11.1
males	278	81.3	4.7
females	320	50.0	16.6
Chi-square = 64.567, df = 2, p = 0.000			
I am career-minded			
all	n=604	61.3	25.3
males	277	58.8	26.4
females	319	63.0	25.1
Chi-square = 1.449, df = 2, p = 0.485			

Table 17 (continued): Attitudes towards various subjects and activities. Percentages

How well do the following statements describe you?	Totals	% Yes	% Not sure
I enjoy writing			
all	n=606	51.8	23.6
males	278	34.5	29.1
females	320	67.2	18.4
Chi-square = 66.950, df = 2, p = 0.000			
I enjoy theories and abstract thinking			
all	n=597	41.9	30.2
males	275	46.9	28.7
females	314	37.6	31.2
Chi-square = 5.797, df = 2, p = 0.055			
I enjoy science			
all	n=605	40.8	17.5
males	278	50.4	19.1
females	319	32.0	16.6
Chi-square = 28.349, df = 2, p = 0.000			
I enjoy technology subjects			
all	n=603	40.5	22.7
males	276	58.0	14.1
females	319	25.4	29.5
Chi-square = 66.191, df = 2, p = 0.000			
I enjoy problem-solving tasks in maths, science or technology			
all	n=604	36.4	20.9
males	276	48.2	19.2
females	320	25.9	22.2
Chi-square = 33.685, df = 2, p = 0.000			
I enjoy maths			
all	n=602	32.4	18.8
males	274	36.9	20.4
females	320	28.8	16.9
Chi-square = 8.107, df = 2, p = 0.017			
I am interested in environmental issues			
all	n=603	30.2	32.7
males	276	24.6	28.6
females	319	35.1	36.4
Chi-square = 21.344, df = 2, p = 0.000			
I enjoy learning another language			
all	n=600	27.5	20.3
males	275	19.3	18.2
females	317	34.1	22.4
Chi-square = 23.300, df = 2, p = 0.000			

Note: Totals for males and females do not sum to totals for all, due to missing values for sex.

Each statement was then crosstabulated with the intention to pursue engineering variable. An analysis of Chi-square statistics indicated that there were no significant differences between the attitudes of 'engineers' and 'non-engineers' on seven of the sixteen statements. These were: enjoy being creative, theories and abstract thinking, being interested in environmental issues, being career-minded, being imaginative and taking part in discussions and debates. However, significant differences between the two groups were found on the remaining nine statements. The 'engineers' were more likely than the 'non-engineers' to enjoy using computers, practical tasks, sport, science, technology subjects, problem-solving tasks and maths (all significant at the 0.01 level or less). The 'non-engineers' were more likely than the 'engineers' to enjoy finding out about people, learning another language and writing (all significant at less than 0.05).

Table 18: Attitudes of 'engineers' and 'non-engineers' towards various subjects and activities. Percentages

How well do the following statements describe you?	Totals	% Yes	% Not sure
I enjoy being creative			
all engineers	n=87	82.8	12.6
males	76	80.3	14.5
females	11	100.0	-
all non-engineers	n=471	74.1	15.7
males	178	82.0	9.6
females	293	69.3	19.5
I enjoy tasks which require me to be imaginative			
all engineers	n=87	74.7	18.4
males	76	72.4	19.7
females	11	90.9	9.1
all non-engineers	n=470	75.7	13.6
males	178	79.2	9.6
females	292	73.6	16.1
I enjoy using computers			
all engineers	n=86	87.2	8.1
males	75	89.3	5.3
females	11	72.7	27.3
all non-engineers	n=472	72.7	12.9
males	177	81.4	9.0
females	295	67.5	15.3
Chi-square = 9.170, df=2, p=0.010			
I enjoy finding out about people			
all engineers	n=87	52.9	24.1
males	76	48.7	26.3
females	11	81.8	9.1
all non-engineers	n=470	77.9	13.2
males	176	64.2	20.5
females	294	86.1	8.8
Chi-square = 24.224, df=2, p=0.000			

Table 18 (continued): Attitudes of 'engineers' and 'non-engineers' towards various subjects and activities. Percentages

How well do the following statements describe you?	Totals	% Yes	% Not sure
I enjoy practical tasks			
all engineers	n=86	87.2	9.3
males	75	89.3	6.7
females	11	72.7	27.3
all non-engineers	n=469	70.4	15.4
males	178	77.5	10.1
females	291	66.0	18.6
Chi-square = 11.851, df=2, p=0.003			
I like taking part in discussions and debates			
all engineers	n=87	67.8	16.1
males	76	67.1	17.1
females	11	72.7	9.1
all non-engineers	n=471	64.3	16.8
males	177	63.3	13.6
females	294	65.0	18.7
I enjoy doing sport			
all engineers	n=87	82.8	4.6
males	76	86.8	3.9
females	11	54.5	9.1
all non-engineers	n=473	60.9	12.5
males	178	78.7	4.5
females	295	50.2	17.3
Chi-square = 16.320, df=2, p=0.000			
I am career-minded			
all engineers	n=86	57.0	25.6
males	75	54.7	29.3
females	11	72.7	-
all non-engineers	n=472	62.9	25.2
males	178	61.2	24.7
females	294	63.9	25.5
I enjoy writing			
all engineers	n=87	31.0	27.6
males	76	27.6	27.6
females	11	54.5	27.3
all non-engineers	n=473	56.4	22.8
males	178	37.6	30.9
females	295	67.8	18.0
Chi-square = 25.521, df=2, p=0.000			
I enjoy theories and abstract thinking			
all engineers	n=87	52.9	21.8
males	76	53.9	22.4
females	11	45.5	18.2
all non-engineers	n=464	39.9	30.8
males	175	44.6	30.9
females	289	37.0	30.8

Table 18 (continued): Attitudes of 'engineers' and 'non-engineers' towards various subjects and activities. Percentages

How well do the following statements describe you?	Totals	% Yes	% Not sure
I enjoy science			
all engineers	n=87	63.2	14.9
males	76	65.8	15.8
females	11	45.5	9.1
all non-engineers	n=472	35.0	18.6
males	178	42.7	20.8
females	294	30.3	17.3
Chi-square = 27.777, df=2, p=0.000			
I enjoy technology subjects			
all engineers	n=86	74.4	9.3
males	75	78.7	5.3
females	11	45.5	36.4
all non-engineers	n=471	33.1	24.6
males	177	48.0	17.5
females	294	24.1	28.9
Chi-square = 54.851, df=2, p=0.000			
I enjoy problem-solving tasks in maths, science or technology			
all engineers	n=87	66.7	13.8
males	76	69.7	14.5
females	11	45.5	9.1
all non-engineers	n=471	29.9	22.3
males	176	38.6	21.6
females	295	24.7	22.7
Chi-square = 46.111, df=2, p=0.000			
I enjoy maths			
all engineers	n=85	48.2	21.2
males	74	51.4	20.3
females	11	27.3	27.3
all non-engineers	n=471	29.1	18.9
males	176	30.1	22.2
females	295	28.5	16.9
Chi-square = 16.180, df=2, p=0.000			
I am interested in environmental issues			
all engineers	n=86	26.7	29.1
males	75	20.0	30.7
females	11	72.7	18.2
all non-engineers	n=471	31.4	34.0
males	177	27.1	29.4
females	294	34.0	36.7
I enjoy learning another language			
all engineers	n=87	16.1	21.8
males	76	13.2	22.4
females	11	36.4	18.2
all non-engineers	n=468	29.7	20.1
males	176	22.7	15.9
females	292	33.9	22.6
Chi-square = 6.325, df=2, p=0.042			

Within the engineers' category, only tentative comparisons could be drawn between male and female 'engineers', due to the small numbers of girls likely to consider a career in engineering. Differences observed were that male 'engineers' appeared to be more inclined than female 'engineers' to enjoy technology subjects, maths, problem-solving tasks and sport. Female 'engineers' seemed much more likely than male 'engineers' to be interested in environmental issues, to enjoy finding out about people, and writing. These latter two preferences they have in common with girls who are not considering engineering, although female 'non-engineers' preferred writing more than female 'engineers'. Female 'engineers' appeared to be more inclined than female 'non-engineers' to be interested in environmental issues, to like being creative, to enjoy technology, problem-solving tasks, science and tasks requiring them to be imaginative. Both groups of girls enjoyed using computers, finding out about people and to a lesser extent, doing sport. Neither group was particularly keen on science (although the female 'engineers' enjoyed it more), maths, or learning another language.

Perhaps the difference most worthy of note is that female 'engineers' appear to be considerably more interested in environmental issues, not only than male 'engineers', but also both male *and* female 'non-engineers'. To a lesser extent, female 'engineers' also appear to be more career-minded than all the other sub-groups, suggesting perhaps that girls willing to consider a 'non-traditional' career such as engineering, would need to be even more motivated and career-minded than other groups. Again, however, it is worth noting that these conclusions can only be tentative, since the female 'engineers' group was very small.

Comparison of male 'engineers' and male 'non-engineers'

Although the small number of female 'engineers' precluded any significance testing between female 'engineers' and other groups, it was, however, possible to make comparisons between male 'engineers' and 'non engineers', using elaboration. This could help to separate out those attitudes that may be common to males in general from those that may be more specific to males likely to consider an engineering career.

An analysis of Chi-square statistics indicated no significant differences between male 'engineers' and 'non-engineers' in their attitudes towards eleven of the sixteen statements. These were: being creative, practical tasks, using computers, taking part in discussions and debates, doing sport, tasks requiring imagination, being career-minded, theories and abstract thinking, writing, learning languages, and environmental issues (these latter three were not popular with either group of males). However, there were differences between the two groups on the remaining five statements. Male 'engineers' were more likely than male 'non-engineers' to enjoy technology subjects (Chi-square statistic = 2.349, df = 2, $p = 0.000$), maths (Chi-square statistic = 11.185, df = 2, $p = 0.004$) problem-solving tasks in maths, science or technology (Chi-square statistic = 21.458, df = 2, $p = 0.000$) and science (Chi-square statistic = 12.022, df = 2, $p = 0.002$). Male 'non-engineers' were more likely than male engineers to enjoy finding out about people (Chi-square statistic = 5.682, df = 2, $p = 0.058$).

Summary: Subject enjoyment

Support was found for the hypothesis that those students considering engineering as a career would be more likely to enjoy technology, science and mathematics and less likely to enjoy writing, learning languages and people-orientated activities than those students not considering a career in engineering. Table 19 compares the percentages of 'engineers' who said they enjoy these subjects, with the percentages of all males and all females who said they enjoy these areas.

Table 19: Percentages of 'engineers', males and females enjoying various engineering-related subjects

Area of curriculum enjoyed	'Engineers'	Males	Females
Maths	48.2	36.9	28.8
Technology	74.4	58.0	25.4
Science	63.2	50.4	32.0
Problem-solving in maths, science or technology	66.7	48.2	25.9

Note: information extracted from tables 18 and 19

Tables 17 and 18 above show that the 'engineers' were more likely than the 'non-engineers' to enjoy using computers, practical tasks, sport, science, technology subjects, problem-solving tasks and maths. The comparison of male 'engineers' and 'non-engineers' showed that those boys likely to consider engineering careers were even more likely than boys in general to enjoy many of these subjects.

Higher levels of enjoyment of science, maths and technology then are associated with positive intentions towards engineering, regardless of sex. However, in general, boys tended to enjoy technology, maths, science and problem-solving tasks in maths, science or technology more than girls. Girls' lesser enjoyment of these engineering-related subjects makes them less likely than boys to choose to study them at post-compulsory level, thus lowering their opportunities in engineering.

Perceptions of subjects

Chapter One discussed the way in which the subject choice process is an important 'filter' for young people, but especially girls, away from later opportunities in engineering. Thus far, this chapter has shown that the girls in this study were less likely than the boys to enjoy mathematics, the physical sciences or technology and less likely to choose to study them. This next section explores this issue further in relation to a widely-used explanation for the low levels of female participation in these subjects, the idea that subjects are sex-stereotyped, leading young people to opt for traditionally 'male' and 'female' subjects, once choice becomes an option (EOC, 2001). The data was collected in order to test the hypothesis that students hold gender-stereotyped perceptions of subjects and that those subjects closely related to engineering are considered 'masculine'.

The gender-stereotyping of school subjects[5]

This section of the Chapter relates to one of the principal hypotheses guiding this research: that negative images of engineering discourage young people from considering it as a career. However, to say that engineering has a 'negative image' can mean one of a number of things and therefore the term needs further definition. Two aspects of the negative image of engineering highlighted in previous research is that engineering is seen as 'masculine' and that this perception discourages girls (and many boys) from pursuing it. The argument that engineering is masculine is extended to the fields of knowledge that underpin it, such as physics, mathematics, technology and computing, which are also argued to be considered male areas of study. Weinreich-Haste (1986: 115), who originally developed this theory in relation to the physical sciences, takes the argument further than this, claiming, not just that science is simply stereotyped as masculine, but that there is a 'constellation of beliefs' around scientific subjects (and by extension engineering). This set of beliefs, she argues, operates to reinforce scientific disciplines as masculine and exclude girls and women from this area. In an early study of student perceptions of subjects, she found that science is considered not only 'masculine', but also 'hard', 'complex', 'based on thinking rather than feeling' and 'about things rather than about people' (1981: 221). Weinreich-Haste's research was replicated by Archer and Freedman in 1989. They also found that engineering, physics mathematics and chemistry were all viewed as masculine (Archer and Freedman, 1989: 311), although their data did not fully support her conclusion that this particular cluster of attributes is uncomplicatedly associated with the masculine-feminine dimension.

[5] Some writers use the term 'gender-stereotyping' and others 'sex-stereotyping'. In this study, these are used interchangeably in accordance with the interpretations of those authors cited.

Replication of previous studies

Some replication of Weinreich-Haste's and Archer and Freedman's work described above was undertaken in the present study for two main reasons. First, their study was undertaken almost fifteen years earlier than this one and it was of interest to establish whether the gendered perceptions of subjects they had found amongst students at that time still held today, or whether there would have been a shift in students' perceptions of academic disciplines towards gender-neutrality. Second, some commentators have claimed that there is not enough replication research in the social sciences (see for example, Neuliep, 1991), not least because there is a bias against publishing replications (Underwager, 2003). This, however, is considered to be a weakness of the social sciences, since it gives 'no chance for what is supposed to be the self-correcting nature of science to work'. Furthermore 'basing decisions on single, unreplicated studies is likely to result in undetermined amounts of error' (Underwager, 2003).

Following both Weinreich-Haste's and Archer and Freedman's studies, respondents in the present study were presented with a list of sixteen subjects and asked to rate them along a five point scale[6] on four dimensions: 'science-art', 'best suited to males-females', 'about things-people' and 'difficult-easy'. Unlike Weinreich-Haste's research, but in keeping with Archer and Freedman's, the measurement scale used in this study contained a neutral mid-point, with 'very' and 'quite' either side. Table 20 summarises the modal answers for each of the subjects on the four dimensions.

[6] Archer and Freedman's study used a seven-point scale.

Table 20: Summary of students' ratings of a selection of school subjects on the four dimensions

Subject	Best suited to males or females?	Science or Art?	Mainly about things or about people?	Difficult or easy?
French	BOTH	ART	BOTH	DIFFICULT
Maths	BOTH	SCIENCE	THINGS	DIFFICULT
Biology	BOTH	SCIENCE	BOTH	EASY
Drama	BOTH	ART	PEOPLE	EASY
Physics	BOTH	SCIENCE	THINGS	DIFFICULT
Sports studies	BOTH	BOTH	PEOPLE	EASY
Chemistry	BOTH	SCIENCE	THINGS	DIFFICULT
English	BOTH	ART	BOTH	EASY
Technology	BOTH	BOTH	THINGS	EASY
Business	BOTH	SCIENCE	BOTH	EASY
History	BOTH	BOTH	BOTH	EASY
Art	BOTH	ART	BOTH	EASY
Engineering	**MALES**	**SCIENCE**	**THINGS**	**DIFFICULT**
Sociology	BOTH	BOTH	PEOPLE	DIFFICULT
Computer studies	BOTH	SCIENCE	THINGS	EASY
Psychology	BOTH	BOTH	PEOPLE	DIFFICULT

Note: The original two categories each side of neutral have been collapsed into one. 'Both' indicates a neutral response.

Table 20 shows that on the 'best suited to males or females' dimension, the majority of respondents rated every subject *except for engineering* as gender-neutral, indicating the enduring association between engineering and masculinity. The rating of all other subjects as neutral in respect of gender suitability by the majority of respondents supports the findings of previous studies, in which young people support an 'equal opportunities' view, but nonetheless make gendered choices themselves (Whitehead, 1996; Francis, 2000). One possible explanation for this response is that it is due to 'social desirability' bias (Oppenheim, 1992: Robson, 1993), defined by Oppenheim (1992: 181) as the tendency for respondents to answer in a way that they believe will reflect socially desirable attitudes 'in order to show themselves in a better light'. This was discussed in Chapter Three in the context of the focus groups, and Francis (2000: 41) suggests that students in interviews 'may be keen to present an equal opportunities view with a face-to-face interview with a female interviewer'. According to Smithson (2000), this kind of bias can also extend to surveys and questionnaires (see also Chapter Six).

Despite the evidence for 'equal opportunities' beliefs, however, a closer look at the frequencies for these subjects on the males-females dimension showed that although the majority of students rated the subjects (except for engineering) as equally suited to males and females, there were nonetheless gender biases amongst the remaining respondents, depending upon the subject in question. To illustrate this point, Table 21 below presents a summary of students' ratings of selected engineering-related subjects. The table shows that for all of these subjects, a much higher percentage of respondents rated them as "best suited to males" than "best suited to females":

Table 21: Percentages of students rating engineering-related subjects along the masculine-feminine dimension. All respondents.

Subject	% rating "Equally suited to both sexes"	% rating "Best suited to males"	% rating "Best suited to females"	Totals
Maths	74.7	22.0	3.3	100.0 (n=601)
Physics	61.9	36.7	1.3	100.0 (n=599)
Technology	62.4	36.4	1.2	100.0 (n=596)
Chemistry	75.7	21.3	3.0	100.0 (n=600)
Computer studies	76.4	21.7	1.8	100.0 (n=598)
Engineering	44.4	55.1	0.5	100.0 (n=601)

Note: The original two categories either side of neutral have been collapsed into one

To find out whether male and female students differed in their ratings of the above-listed subjects, crosstabulations were computed on the three-category variable for each subject. An analysis of Chi-square statistics indicated no significant differences between males and females in their ratings of maths, physics, chemistry and engineering. However, technology was more likely to be seen as a 'male' subject by the male students, 46% of whom rated it "best suited to males", compared with only 28% of the female students (Chi-square statistics are not reported as cell counts were low in the "Best suited to females" category). In contrast, the female students were much more likely than the males to rate technology as "equally suited to both sexes" (71% of females, compared with only 54% of males). Computer studies too was more likely to be seen as a 'male' subject by the male students, 28% of whom rated it as "best suited to males", compared with only 16% of the female students (Chi-square = 10.671, df = 2, p = 0.005).

In Archer and Freedman's 1989 study, an alternative technique of analysis had been used from that of the frequencies and crosstabulations reported above. They had computed one-sample t-tests (see George and Mallery, 2001) on each of the various dimensions in their study, to find out how far the mean ratings of each academic discipline differed from neutral. To further develop the replication research here, one-sample t-tests were similarly performed on the four dimensions used in the present study. This could serve to show whether the findings reported above from the frequencies and crosstabulations, continued to hold when using a different technique of analysis. However it is worth noting again, that in this study, the attitude measures are understood, not as fixed psychological attributes of individuals, but rather as indicators of how the students positioned themselves in relation to the underlying social construction of meanings that are attached to academic disciplines.

Masculine or feminine?

For the masculine-feminine dimension, Archer and Freedman had found that engineering, physics, chemistry and maths were all significantly different from neutral in the masculine direction, and that English, biology, psychology, French and sociology were significantly different from neutral in the feminine direction (see Illustration A below). The only subject on Archer and Freedman's list rated as neutral was German (a subject not included in the present study).

Illustration A : Mean masculine-feminine ratings of academic disciplines for all 60 students (Archer and Freedman, 1989: 308)

Academic discipline	Mean rating	Difference from neutral (t-value)	Significance level P
Engineering	2.15	-11.76	<0.0001
Physics	2.73	-8.24	<0.0001
Chemistry	3.23	-6.67	<0.0001
Maths	3.52	-4.29	<0.0001
German	4.17	1.49	NS*
English	4.32	3.38	<0.001
Biology	4.32	2.75	<0.001
Psychology	4.40	4.06	<0.0001
French	4.42	4.10	<0.0001
Sociology	4.43	3.31	<0.001

Note: a rating of 1 indicates complete agreement with masculine, while a rating of 7 indicates complete agreement with feminine. A neutral rating is 4. * = not significant.

In the present study, for the masculine-feminine dimension, in agreement with Archer and Freedman, it was found that engineering, physics, mathematics and chemistry were significantly different from neutral in the masculine direction and biology, psychology, French, sociology and English were significantly different from neutral in the feminine direction (see table 22 below). In Archer and Freedman's study, engineering had been the most stereotypically masculine and sociology the most feminine subject. In the present study, as, expected, engineering remained the most stereotypically masculine subject, but English was the most feminine subject, with sociology in second place. History was found to be the only subject rated as neutral (a subject not included in Archer and Freedman's study), supporting the findings of other studies (Colley, et al., 1994; Whitehead, 1996).

Table 22: Mean Masculine-Feminine ratings of subjects for all respondents (N=606)

Subject	Mean rating	Difference from Neutral (t-value)	Significance level P
Engineering	2.2762	-23.566	<0.0001
Sports Studies	2.5417	-16.277	<0.0001
Technology	2.5654	-15.913	<0.0001
Physics	2.5626	-15.605	<0.0001
Computer studies	2.7575	-10.198	<0.0001
Mathematics	2.7804	-9.303	<0.0001
Chemistry	2.7817	-9.155	<0.0001
Business studies	2.9383	-3.011	<0.01
History	3.0285	1.394	NS*
Biology	3.0650	2.901	<0.01
Art	3.1639	7.181	<0.0001
Psychology	3.1733	8.018	<0.0001
Drama	3.2400	9.540	<0.0001
French	3.2396	10.739	<0.0001
Sociology	3.2433	10.859	<0.0001
English	3.3062	12.882	<0.0001

Note: a rating of 1 indicates complete agreement with masculine, while a rating of 5 indicates complete agreement with feminine. A neutral rating is 3. * = not significant.

To find out whether the mean ratings of male and female students differed on the masculine-feminine dimension, the means of males' and females' ratings for each subject were then compared, using independent samples t-tests. These found that on the masculine-feminine dimension, there were no significant differences between the males' and females' ratings on eight of the subjects: mathematics, drama, physics, chemistry, English, art, sociology or psychology. However, there was a statistically significant association between gender and ratings for the remaining eight subjects. The male students were more likely than the female students to rate French further from neutral in the feminine direction and the female students were more likely than the males to rate biology as further from neutral in the feminine direction. Males rated sports studies, technology, business studies, history, engineering and computer studies further from neutral in the masculine direction (all of these were significant at the 0.05 level of probability or below).

Science or art?

On the science-arts dimension, Archer and Freedman found that physics, chemistry, biology, engineering, maths and psychology were rated as significantly different from neutral in the science direction, whilst French, German and English were rated as significantly different from neutral in the arts direction as shown in Illustration B below:

Illustration B : Mean science-arts ratings of academic disciplines for all 60 students (Archer and Freedman, 1989: 308)

Academic discipline	Mean rating	Difference from neutral (t-value)	Significance level P
Physics	1.12	-59.97	<0.0001
Chemistry	1.18	-38.46	<0.0001
Biology	1.55	-20.05	<0.0001
Engineering	2.10	-14.20	<0.0001
Maths	2.38	-10.61	<0.0001
Psychology	3.15	-5.34	<0.0001
Sociology	3.77	-1.46	NS*
French	5.43	9.86	<0.0001
German	5.55	9.36	<0.0001
English	5.73	11.55	<0.0001

Note: a rating of 1 indicates complete agreement with masculine, while a rating of 7 indicates complete agreement with feminine. A neutral rating is 4. * = not significant.

A similar analysis was carried out on the science-arts dimension for the present study (see Table 23 below). The present study supported Archer and Freedman's results in that the same subjects were rated as significantly different from neutral in the science and art directions (German was not included in the present study). Differences between this study and Archer and Freedman's were first, that Archer and Freedman found that physics was the most stereotypically scientific subject, whereas in the present study physics was in second place to chemistry. Second, Archer and Freedman had found that English was the most strongly stereotyped arts subject, whereas in the present study, English took third place after art and drama, subjects that were not included in Archer and Freedman's original list. Third, in Archer and Freedman's study, sociology was not rated as significantly different from neutral, whereas in the present one, sociology was significantly different from neutral in the science direction.

Table 23: Mean Science-Art ratings of subjects for all respondents (N = 606)

Subject	Mean rating	Difference from Neutral (t-value)	Significance level P
Chemistry	1.1765	-87.225	<0.0001
Physics	1.1936	-78.455	<0.0001
Biology	1.3350	-64.513	<0.0001
Mathematics	1.6633	-47.021	<0.0001
Computer Studies	2.0135	-30.370	<0.0001
Engineering	2.0557	-25.253	<0.0001
Business Studies	2.4686	-16.854	<0.0001
Psychology	2.5120	-12.165	<0.0001
Technology	2.6571	-8.644	<0.0001
Sports studies	2.7915	-5.538	<0.0001
Sociology	2.8241	-4.731	<0.0001
History	2.9580	-1.091	NS*
French	3.6188	20.300	<0.0001
English	3.6945	21.247	<0.0001
Drama	4.7071	66.946	<0.0001
Art	4.8454	77.619	<0.0001

Note: a rating of 1 indicates complete agreement with science, while a rating of 5 indicates complete agreement with art. A neutral rating is 3. * = not significant.

Things or people?

One-sample t tests on the 'things-people' dimension (see Table 24) revealed that mathematics was rated as most different from neutral in the 'about things' direction, whereas drama was rated as most different from neutral in the 'about people' direction. Business Studies was the subject in which respondents' ratings were closest to neutral.

Table 24: Mean Things-People ratings of subjects for all respondents (n=606)

Subject	Mean rating	Difference from Neutral (t-value)	Significance level P
Mathematics	2.000	-26.133	<0.0001
Engineering	2.2191	-21.655	<0.0001
Physics	2.2692	-19.341	<0.0001
Chemistry	2.3076	-18.583	<0.0001
Technology	2.2864	-18.523	<0.0001
Computer studies	2.3149	-18.372	<0.0001
Art	2.8848	-3.204	0.001
Business studies	3.0886	2.382	<0.05
Biology	3.1733	4.153	<0.0001
English	3.4303	13.300	<0.0001
History	3.6030	16.471	<0.0001
French	3.6461	16.974	<0.0001
Sports studies	3.7963	21.608	<0.0001
Sociology	3.9530	24.317	<0.0001
Psychology	4.0719	26.688	<0.0001
Drama	4.1298	29.870	<0.0001

Note: A rating of 1 indicates complete agreement with things, while a rating of 5 indicates complete agreement with people. A neutral rating is 3.

Difficult or easy?

On the 'difficult-easy' dimension (see Table 25), all subjects were rated as significantly different from neutral, with business studies closer to neutral than the other subjects. Chemistry was rated as most different from neutral in the 'difficult' direction, whereas art was rated as most different from neutral in the 'easy' direction.

Table 25: Mean Difficult-Easy ratings of subjects for all respondents (n=606)

Subject	Mean rating	Difference from Neutral (t-value)	Significance level P
Chemistry	2.5896	-8.685	<0.0001
Physics	2.5841	-8.647	<0.0001
Mathematics	2.6739	-7.194	<0.0001
French	2.6526	-6.136	<0.0001
Psychology	2.4146	-3.576	0.001
Engineering	2.4783	-3.078	<0.01
Sociology	2.6393	-2.409	<0.05
Business studies	3.1765	1.972	0.05
Biology	3.0946	2.135	<0.05
History	3.1549	2.177	<0.05
Computer studies	3.5761	5.061	<0.0001
English	3.2265	5.202	<0.0001
Technology	3.3905	8.483	<0.0001
Sports studies	3.6978	9.053	<0.0001
Drama	3.9154	11.858	<0.0001
Art	3.7899	11.967	<0.0001

Note: a rating of 1 indicates complete agreement with difficult, while a rating of 5 indicates complete agreement with easy. A neutral rating is 3.

Summary: perceptions of school subjects

Frequency tables showed that all subjects *with the exception of engineering* were rated as gender neutral on the masculine-feminine dimension by the majority of respondents. However, when one-sample t-tests were computed to test for any significant departures from the neutral rating, it was found that the students' perceptions of *all* subjects differed significantly from neutral on the masculine-feminine dimension as well as on the other three dimensions (science-art, things-people and difficult-easy). The only exception to this was history, which was neutral on the masculine-feminine and also on the science-art dimensions. This discrepancy in results using two different statistical techniques illustrates well the need to interpret such findings with caution. However, it is important to note that the rating of engineering as 'best suited to males' held in the case of both examples.

Weinreich-Haste (1981) had claimed that there is a *cluster* of attributes attached to scientific disciplines, in that subjects considered scientific are also considered masculine, hard, complex, based on thinking rather than feeling and about things rather than about people. To extend Weinreich-Haste's hypothesis to *engineering*-related disciplines in this study, it had been hypothesised that engineering-related subjects would be perceived as masculine, scientific, about things and difficult. Examining frequency tables showed that this hypothesis held for only one subject, notably this was engineering (refer to Table 20). However, further support for Weinreich-Haste's hypothesis was provided when using the one-sample t-tests, which found that *four* subjects closely-related to engineering were concurrently rated as masculine, scientific, about things and difficult. These subjects were engineering, mathematics, chemistry and physics. This may well suggest that the stereotypes attached to these subjects are slow to change. However, despite the correspondence between masculinity and the other three dimensions for these four subjects, this 'cluster' did not hold for two other subjects closely related to engineering: technology and computer studies. Although these two subjects were rated as masculine, scientific and about things, technology and computer studies were concurrently rated as 'easy', as opposed to difficult. This offers support for the conclusion reached by Archer and Freedman (1989) that the *cluster* of perceptions Weinreich-Haste associated with the masculine-feminine dimensions does not necessarily hold in all cases. Views of technology as a subject are especially problematic to assess, in the sense that there are a number of diverse courses on offer at GCSE and A-level, from electronics and graphics, to food and textiles, some of which may be considered more difficult than others.

Chapter summary and conclusion

This chapter has presented and discussed findings from the first half of the Year 12 survey, which collected data relating to the students' intentions towards engineering careers, the subjects they had chosen to study, the factors influencing their subject choices, their subject enjoyment and preferences, and their perceptions of subjects as 'masculine', 'feminine' or 'neutral'. In particular, the chapter set out to test the hypotheses that academic disciplines relating to engineering are gender-stereotyped as masculine. It was found that 16% of the students were likely to *consider* a career in engineering, while 6% had made it an actual career choice. This latter is a proportion broadly consistent with the percentage of students accepted to engineering degree courses as a proportion of all higher education 'applicants accepted' for each of the years 1999 to 2001 (Engineering Council, 2002). As expected, engineering was not a popular career option for girls, with male students almost seven times more likely than females to consider an engineering career. With regard to subjects foundational to engineering, despite claims about the declining popularity of mathematics and physics, mathematics was the second most widely studied A-level subject amongst this sample of students and physics was in the 'top ten'. However, there was also a statistically significant association between gender and studying the physical sciences or technology, with males much more likely to do so than females.

Some key conclusions of this Chapter are that being male, studying physical sciences or technology subjects, enjoying physical sciences or technology subjects, having a parent in Class 1 (Managerial and Professional) and being related to an engineer, were all predictors of positive intentions towards engineering careers. Students considering a career in engineering also tended to avoid subjects of study involving written work and were attracted to subjects that are practical and 'hands on'. These were all ways of positioning oneself that tend to be more typical of males than females. Despite evidence for students' beliefs in gender equality, the data on perceptions of academic disciplines showed that stereotypes attached to subjects have been slow to change and offered strong support for the hypothesis that engineering-related subjects have a masculine image. The perception that engineering itself is best suited to males was particularly strong amongst the respondents.

Chapter Five enlarges the analysis further by presenting and discussing data from the second half of the Year 12 survey, which was concerned with issues relating to the students' career aspirations and their perceptions of engineering as a career. This chapter set out to test a number of hypotheses relating to the principal hypothesis that engineering is perceived as a masculine occupation. It does this by examining the students' images and perceptions of engineering, in relation to a number of other variables.

CHAPTER FIVE:

Career aspirations and attitudes towards engineering

Introduction

Chapter Four presented the data relating to the first half of the survey, focusing on the students' subject choices, preferences and intentions towards engineering careers. This Chapter presents data relating to the second section of the survey, which sought information relating more specifically to the hypothesis that engineering has a negative image. In particular, this data tests the hypothesis that engineering is gender-stereotyped as a masculine occupation, but it also set out to test a number of further hypotheses relating to other aspects of engineering's 'negative image', some of which may simultaneously serve to support its masculine image. These include the hypotheses that women in engineering work face hostility from male colleagues; that the demands of the job make balancing career and family difficult; that engineers are stereotyped as 'asocial', and that engineering is not a 'people' job.

The data presented is organised into five main sections: 1) career aspirations, 2) 'work values', 3) knowledge about engineering, 4) perceptions of engineering and engineers, and finally 5) attitudes towards engineering as a career. In the section of the questionnaire covered in this Chapter, students were asked about their career aims, the kinds of things they seek in a career (work values), and their level of knowledge about particular occupations (including engineering). The questionnaire also measured the students' perceptions and images of engineers and engineering and their attitudes towards engineering as a career. The students' responses are analysed by gender and intentions towards engineering throughout, to find out if there are differences and similarities between the sub-groups in terms of their perceptions and attitudes.

Career aspirations

Chapter Four described the characteristics of students in the sample who had said they would *consider* engineering as a career and then proceeded to explore the relationship between positive intentions towards engineering and a number of variables relating to subject choices and preferences. A later section of the survey was also interested in the students' *actual* career aspirations in order to assess the extent to which these might be gender divided and to compare the number of students who had chosen engineering with the proportions of students who had said they were likely to *consider* it. This information could help to assess more accurately the degree of commitment towards engineering as a career choice amongst the sample and to find out if this differed for males and females.

Respondents were asked if they had any general career plans and if so, to state their first choice of occupation. More than two thirds (68%) of all respondents said they had career plans, males and females in equal proportions. The occupations stated by the students were grouped into the twenty-five occupational categories shown in Table 26 below (see Appendix V for a complete list of the occupations stated and their allocation to the groups). As had been found in the focus groups, engineering and teaching were popular career aspirations. Teaching was by far the most frequently aspired to occupation, constituting 14% of all those in the sample with career plans, which is twice the proportion of any other category. Engineering was the joint third largest category, along with Business, each containing 6% of those with career aspirations (24 respondents).

When the frequencies for the occupational categories were analysed by gender, a traditional pattern of gendered career aspirations emerged (see Table 26). Chi-square analysis revealed that the observed relationship between gender and career aspirations was a significant one (Chi-square statistic = 124.693, df =18, p= .000). Based on a sex ratio no greater than 60:40, only four of the twenty-five occupational categories can be classified as gender neutral, these are: 1) art, design and graphics, 2) business, 3) science-based work and 4) media. Teaching, the most frequently mentioned occupation, was dominated by females, who constituted 82% of the category. Of those occupations *containing ten or more* respondents, the most 'feminine' were personal service work (e.g. beautician, flight-attendant) and child-related work, both of which contain no males at all. The most 'masculine' occupations were engineering (96% males) and computer-related work (95% male).

Table 26: Career aspirations by gender. All respondents.

	% of all students	Males as a % of category	Females as a % of category
Teaching	13.6 (n=55)	18.2	81.8
Armed Forces	6.9 (n=28)	82.1	17.9
Business	6.0 (n=24)	56.5	43.5
Engineering	6.0 (n=24)	95.7	4.3
Entertainment/Performing arts	5.7 (n=23)	34.8	65.2
Computer-related work	5.2 (n=21)	95.2	4.8
Art, Design & Graphics	5.0 (n=20)	50.0	50.0
Police & Emergency Services	4.7 (n=19)	66.7	33.3
Science-based work	4.7 (n=19)	47.4	52.6
Nursing	4.0 (n=16)	6.3	93.8
Animal-related work	3.5 (n=14)	35.7	64.3
Personal Services	3.2 (n=13)	0	100.0
Law	3.2 (n=13)	16.7	83.3
Sport-related work	3.2 (n=13)	69.2	30.8
Child-related work	3.0 (n=12)	0	100.0
Media	3.0 (n=12)	41.7	58.3
Tourism	2.7 (n=11)	27.3	72.7
Social work & Care	2.2 (n=9)	11.1	88.9
Medicine, Allied to medicine & Dentistry	2.0 (n=8)	37.5	62.5
Languages	1.5 (n=6)	33.3	66.7
Psychology & Counselling	1.5 (n=6)	33.3	66.7
Clerical & Administrative	1.2 (n=5)	20.0	80.0
Architecture & Construction	1.2 (n=5)	80.0	20.0
Craft/Trades	0.5 (n=2)	100.0	0
Catering	0.5 (n=2)	100.0	0
Other, or Unable to classify	5.7 (n=23)	54.5	45.5

The five most popular aspirations for boys were armed forces (13% of all boys with career plans), engineering (12%), computer-related work (11%), business (7%) and police and emergency services (7%). For girls, the five most popular occupations were teaching (21% of all girls with career plans), nursing and entertainment/ performing arts (both at 7%), personal services work (e.g beautician, flight attendant) (6%) and child-related work (6%). The observed patterns of career aspiration are typical of traditional choices made by girls and boys, and mirror the patterns found in other studies (Whyte, 1986; Darling and Glendinning, 1996).

Stated career aspirations of respondents likely to consider a career in engineering

In his study of young people's career intentions, Winter (1992) found that there was an incongruity between the proportion of young people saying they would *consider* engineering and the actual number choosing it. It was therefore informative to find out if there was a similar disparity in this study, to assess more accurately the level of commitment towards engineering amongst this sample of students and to assess the soundness of the variable 'likely to consider engineering'.

Of the 89 students who were likely to consider engineering ('engineers'), three-quarters (75%) had career aims and had stated specific careers. However, only 29% of these (26 students) had stated the word 'engineering' in either their first or second career choice. Nonetheless, many of the occupations the male 'engineers' stated could fall into the category of engineering. These included armed forces, computer-related work, crafts/trades, architecture and construction, apprenticeships and aerospace. Only five of these 76 boys stated occupations in their first and second career choices that were completely unconnected to engineering. The actual career aspirations of the female 'engineers' revealed a rather different picture. Ten of these eleven girls had career aspirations, but only two of the girls had stated 'engineering' explicitly in either their first or second choice. However three more girls had stated occupations that might be related to, or categorised as, engineering. These were 'computer-related work', 'science-based work' and 'mechanic'. The five remaining girls had stated occupations as their first and second choices that were completely unrelated to engineering. This indicates that the majority of the boys who had said they would consider a career in engineering appeared to actually aspire to it, whereas fewer than half of the girls did, suggesting that the girls had a lower level of commitment to engineering than the boys. It would seem therefore, that the 'likely to consider engineering' variable was a more reliable measure in relation to males' actual aspirations than it was to females', although the female 'engineers' were so few in number that it was not possible to draw firm conclusions about this.

Work values

A central aim of this study was to investigate the factors attracting young people to and/or discouraging them from engineering careers. One way of doing this was to find out what students are most looking for in a job or career and compare the 'engineers' and the 'non-engineers' in terms of these 'work values'. The objective was to find out whether the two groups of students differ in terms of what they are seeking from their future occupations. Males and females were also compared for any similarities and differences.

A list of fifteen 'work values' was compiled from previous studies of young people and career choice (see Lips, 1992; Lightbody et. al, 1994; Fuller, 1991; Woolnough, 1994) and from the findings of the focus group interviews. Respondents were asked to choose from the list the one factor that would be most important to them in a job or career. The three most popular answers for respondents as a whole were 'good money', chosen by just over one quarter of all respondents (28%), followed by 'self-fulfilment' (17% of respondents) and 'chance to help others' (9% of respondents).

Gender was found to have an impact on what is considered important in a career (see Table 27 below). 'Good money', the most commonly chosen factor, was more important to males (61% of those choosing it) than it was to females. 36% of all boys believed money to be the most important factor they sought in a job, compared with only 20% per cent of all girls. The second most popular factor, 'self-fulfilment', was more important to females, who were 68% of those choosing it, than it was to males. In fact, self-fulfilment was the top answer for girls, 22% of whom chose it, compared with only 12% of boys. The third most popular answer, 'chance to help others', was again much more important to females (83% of those choosing it) than it was to males. 13% of girls in the sample chose it as their most important factor, compared with only 3% of the boys.

For males in the sample then, the attribute most sought after in a job or career was good money. In second place was self-fulfilment and in third place, excitement. Females most sought self-fulfilment, followed by good money and, in third place, the chance to help others. The sexes were most in agreement in their desire 'to make things', although this was chosen as the most important factor by only two respondents, one male and one female. The sexes also more or less equally valued the 'ability to combine career and family', which was chosen as the most important factor by 7% of respondents, females forming 51% and males 49% of this category. This finding was unexpected, as previous studies have suggested that females, who have traditionally carried the responsibility for childcare, would prioritise the flexibility to combine a career and a family more than males.

Table 27: Most important factor sought from a job or career, by gender

	Males as a % of category	Females as a % of category	Frequency n=
1. good money	60.9	39.1	151
2. self-fulfilment	31.9	68.1	94
3. chance to help others	17.4	82.6	46
4. excitement	54.8	45.2	42
5. job-security	41.0	59.0	39
6. ability to combine career and family	48.6	51.4	35
7. chances for advancement	60.6	39.4	33
8. variety	57.9	42.1	19
9. contact with other people	17.6	82.4	17
10. status and respect from others	53.3	46.7	15
11. the challenge of difficult work	61.5	38.5	13
12. to make my own decisions	54.5	45.5	11
13. outdoor environment	30.0	70.0	10
14. to become famous	75.0	25.0	8
15. to make things	50.0	50.0	2
16. other	46.6	53.4	8

Crosstabulating by intention towards engineering compared the answers of those likely and those unlikely to consider a career in engineering. Whilst good money was the most important factor for both these groups, it was more important to 'engineers' than it was to 'non-engineers'. More than one third of those likely to consider engineering chose it (38%), compared with approximately one-quarter (26%) of those unlikely to consider engineering. Self-fulfilment was the second most popular answer with both groups, but it was more important to 'non-engineers', 18% of whom chose it, compared with 12% of 'engineers. In third place for 'engineers' was excitement, chosen by 9%, whereas for 'non-engineers', the third most popular answer was 'chance to help others', chosen by 10%.

The top three answers of 'Scientists/technologists' and 'non scientists/technologists' were also compared and found to differ. Whereas 'scientists/technologists' chose good money as the most important factor, the 'non scientists/technologists', like the females, chose self-fulfilment as the first factor and good money as the second. In common with females and respondents as a whole, 'to help others' was the third most important factor for 'non scientists/technologists'. The 'scientists/technologists' differed from all other groups in selecting 'to combine career and family' as their third most important factor. Table 28 below illustrates the way the different groups of students prioritised different factors. It summarises the top three factors for each of the different groups and the percentages choosing them.

Table 28: Factors most sought after in a job or career. Top three answers for all respondents and various sub-groups

Respondents	1st factor	%	2nd factor	%	3rd factor	%
all	good money	27.6	self-fulfilment	17.1	to help others	8.3
males	good money	36.4	self-fulfilment	11.9	excitement	9.1
females	self-fulfilment	22.1	good money	20.3	to help others	13.1
engineers	good money	38.3	self-fulfilment	12.3	excitement	8.6
non-engineers	good money	25.8	self-fulfilment	18.4	to help others	9.9
scientists/ technologists	good money	34.0	self-fulfilment	12.2	combine career and family	9.5
non-scientists/ technologists	self-fulfilment	24.5	good money	22.1	to help others	9.1

By way of a summary, Table 29 below compares the different sub-groups of students in the top three answers only. The table shows, perhaps unsurprisingly, that the most divergence in views is between the 'engineers' and females. Although good money was the most important factor amongst respondents as a whole, 'engineers' are the group most likely to prioritise it, and females the least likely. Conversely, females were the group most likely to want a job giving them the chance to help others (13% of females), and 'engineers' the group the least likely to choose this (only 1% of engineers).

Table 29: The three factors considered most important in a job or career by all respondents and various sub-groups

	1st factor Good money %	2nd factor Self-fulfilment %	3rd factor To help others %
all (n=551)	27.6	17.1	8.3
Males (n=253)	36.4	11.9	3.2
Females (n=290)	20.3	22.1	13.1
Engineers (n=81)	38.3	12.3	1.2
Scientists/technologists (n=147)	34.0	12.2	4.8

Summary: Work values

High earnings ('good money') was the most important factor in a job to respondents as a whole and to all of the sub-groups, with the exception of females and 'non-scientists/technologists', who said self-fulfilment was most important. Gender would appear to explain most of the differences between 'engineers' and 'non-engineers', with the 'engineers' prioritising the same three factors as males in general, and the 'non-engineers' prioritising the same three factors as females in general, although in a slightly different order (see Table 28). Similarly, gender explains most of the differences between 'scientists/technologists' and 'non-scientists/technologists', with this latter group choosing the same three factors as females in general. The 'scientists/technologists' had the same factors in first and second place, but differed on the third most important factor, which, for males, was excitement, but for 'scientists/technologists', rather surprisingly, was 'ability to combine career and family'.

Good money was more important to potential engineers than it was to any of the other groups. Table 29 showed that 38% of the 'engineers' had chosen good money as the most important factor, compared with only 28% of all respondents. This finding supports those of Woolnough (1994) and indicates that engineering is thought to be a well-paid profession by those considering it as a possible career. It also disputes the hypothesis that young people are discouraged from engineering because it is seen as poorly paid in comparison with other professions (see for example, Mylius, 2001). However, the finding that 'engineers' were the group least likely to prioritise the value 'to help others', offers some support for the hypotheses that engineering is perceived as 'inhumane', 'asocial', or 'unethical', other reported dimensions of engineering's negative image (Glover, 1980; Fuller, 1991; Glover and Fielding, 1999).

Knowledge about engineering

This section presents data relating to the students' levels of awareness and knowledge about engineering. It has been argued that one factor contributing to the negative image of engineering is that there is a general lack of awareness and knowledge about it, or that misconceptions are held (Glover and Kelly, 1987; Foskett and Hemsley-Brown, 1997). In consequence, the possibilities and potential of engineering as a career choice may not be immediately apparent. This is therefore believed to be one of the factors contributing to the low numbers of young people who decide to pursue it (see MORI, 2001). One of the concerns of the engineering institutions has been that, until fairly recently, the educational curriculum has not exposed young people to engineering in any direct manner. Consequently, some engineering institutions have run initiatives aimed at promoting engineering as a career in schools, in order to give pupils an awareness of the nature of the work and the opportunities involved.

This part of the survey aimed to test the hypothesis that low levels of knowledge about engineering are associated with low aspirations towards engineering. It asks whether those respondents who feel they know a lot about engineering are more likely to consider it as a career than those who know only a little about it. It involved finding out how much the students in this sample felt they know about engineering and making comparisons in terms of intentions towards engineering and by gender. Certainly, there was evidence to support this hypothesis in the preceding focus group interviews, which had found that the majority of participants, and females in particular, felt they did not know much about engineering.

In the questionnaire, respondents were asked to indicate whether they knew 'nothing at all', 'not much', 'a little', 'quite a lot' or 'a lot' about engineering. The results (see Table 30 below) supported the focus group findings. About two-thirds of all respondents (64%) said they knew 'nothing at all' or 'not much' about engineering. About one fifth (21%) said they knew 'a little' and the smallest proportion (15%) knew 'quite a lot' or 'a lot'. However, although the majority of both sexes reported that they knew little about engineering, males and females were not equally distributed in these answer categories (see Table 30). Females were much less likely to say they know anything about engineering than were males and the higher the level of knowledge about engineering, the fewer females were to be found. This observed relationship between level of knowledge about engineering and gender was statistically significant (Chi-square = 95.729, df = 4, p= .000)

Table 30: Level of knowledge about engineering, by gender

Level of knowledge about engineering	% male	% female	Frequency n=
nothing at all	27.7	72.3	191
not much	38.6	61.4	184
a little	59.0	41.0	122
quite a lot	88.5	11.5	61
a lot	83.3	16.7	24

The next step in the analysis was to examine the relationship between level of knowledge about engineering and intention to pursue it as a career. A cross-tabulation of these variables indicated that the greater the knowledge of engineering held, the more likely the respondent was to consider it as a career (see Table 31). For example, of those who were 'very likely' to consider engineering as a career, 67% said they knew 'quite a lot' or 'a lot' about engineering and only 13% said they knew 'nothing at all' or 'not much'. This relationship was a statistically significant one (Chi-square = 260.697, df = 12, p = .000).

Table 31: How likely to consider engineering by level of knowledge held about engineering. All respondents.

	Level of knowledge about engineering				
	% "nothing at all"	% "not much"	% "a little"	% "quite a lot"	% "a lot"
How likely to consider engineering					
very unlikely	47.6	35.1	14.1	2.1	1.1
fairly unlikely	5.0	43.6	31.7	14.9	5.0
fairly likely	6.8	9.1	36.4	36.4	11.4
very likely	6.7	6.7	20.0	44.4	22.2

A further section of the questionnaire provided a second opportunity to test the relationship between levels of knowledge and intentions towards engineering. Here, respondents had been asked to indicate their level of knowledge not only about engineering, but also about a number of other occupations. To assess their knowledge of what each job entails, respondents were asked: "*how much would you say you know about what people in the following jobs do in their work*?". Table 32 below shows the percentages of respondents answering 'nothing/not much', 'a little' or 'quite a lot/a lot' for each of the eleven occupations. Respondents knew most about a teacher's job, with approximately three-quarters (74%) saying they knew 'quite a lot' or 'a lot' and only 7% saying they knew 'nothing' or 'not much'. In contrast, respondents felt they knew the least about an engineer's job, with more than half (53%) of respondents saying they knew 'nothing' or 'not much' and less than one-quarter (24%) saying they knew 'quite a lot' or 'a lot'.

Table 32: Respondents' levels of knowledge about the nature of selected occupations. All respondents. Percentages.

Occupation	'Nothing'/'Not much'	'A little'	'Quite a lot'/'A lot'
Teacher	6.5	19.9	73.6
Secretary	20.0	33.1	47.0
Fire-fighter	23.9	32.2	43.9
Police officer	20.1	36.4	43.5
Nurse	24.1	33.9	42.0
Vet	34.3	29.4	36.3
Journalist	30.8	36.0	33.3
Solicitor	40.2	34.6	25.2
Graphic designer	49.2	25.1	25.6
Engineer	52.8	23.2	23.9
Accountant	37.4	38.9	23.8

So is there a relationship between the amount of knowledge held about an occupation and the likelihood of pursuing it as a career? Certainly, in this study, teaching, as the occupation respondents knew most about, was also the most frequently stated career aspiration (see table 32 above), supporting the hypothesis that the more that is known about a job, the greater the likelihood of choosing to pursue it. However, it is not surprising that the students have knowledge of teaching, since they might reasonably be expected to have an insight into the nature of a teacher's job from their day-to-day school experience. Like teaching, engineering came high on the list of career aspirations, but was nonetheless, the occupation the students felt they knew least about. Conversely, 'secretary' was the second-most 'known about' occupation, but was not the actual career intention of any respondent, probably because most of the students in this sample were aspiring to higher status occupations.

The relationship between intention to pursue a particular occupation and having knowledge about it was further explored by comparing selected occupations. For example, although the majority of all respondents (74%) said they knew more about teaching than any of the other listed jobs, those planning to pursue it as a career knew more than those choosing other occupations. Almost all (98%) of those choosing teaching as their first choice of career said they knew 'quite a lot' or 'a lot' about a teacher's job, compared with only 74% of those choosing occupations other than teaching (Chi-square = 30.889, df = 4, p = .000). Similarly, 87% of those who wanted to go into nursing said they know 'quite a lot' or 'a lot' about a nurse's job, compared with only 45% of those not choosing nursing. The differences in the amount of knowledge held about engineering between those making it an actual career choice and those not doing so was even more marked. 83% of those stating engineering as their first career choice said they knew 'quite a lot', or 'a lot' about an engineer's job, compared to only 22% of those planning to pursue occupations other than engineering.

Summary: knowledge about engineering

These findings tend to support the hypothesis that having a greater awareness and knowledge of engineering increases the likelihood of pursuing it as a career. However, it is not possible to tell from this data whether the students' knowledge about engineering had led to the decision to pursue it as a career, or the decision to pursue engineering had led to the students' finding out more about it and hence, 'knowing' more. Further investigation would be needed in order to establish the causal direction of this association. The data also says little about the amount the respondents actually know, only what they *think* they know.

Perceptions of engineering and engineers

This part of the survey examined the students' images, insights and awareness of engineering by using a word-association technique with the aim of finding out what the students typically believed that engineers do. In particular it set out to find out whether perceptions of engineering differed by gender and intentions towards engineering.

Words associated with engineering

In order to elicit the respondents' perceptions of engineering and engineers, they were asked the open-ended question "*What are the first words you think of when you hear the word 'engineer'?*". The majority of respondents wrote in one or two words, although many wrote down several, conveying an overall impression of engineering. In the initial analysis of this data, the *first* word mentioned by each respondent was entered directly into SPSS in the form of a string variable. This allowed frequencies to be obtained for the number of times each word was mentioned. Percentages were then calculated of all respondents and the various subgroups mentioning each of these words. Table 33 below summarises the five most frequently mentioned words for all respondents and the various sub-groups.

Table 33: The five words most frequently associated with engineering

		Males	Females	All
1. Cars		8.5	17.1	13.1
	engineers	4.1	9.1 (n=1)	4.7
	non-engineers	9.8	17.8	14.8
2. Machines/machinery		7.7	13.7	10.8
	engineers	4.1	0.0	3.5
	non-engineers	9.8	14.2	12.4
3. Fixing		7.7	7.5	7.5
	engineers	8.2	0.0	7.0
	non-engineers	6.9	8.0	7.5
4. Mechanic/mechanics		6.9	6.5	6.6
	engineers	8.2	18.2 (n=2)	9.3
	non-engineers	6.9	6.2	6.4
5. Engines		6.2	4.8	5.4
	engineers	4.1	0.0	3.5
	non-engineers	6.9	5.1	5.8

Note: since these categories were derived from qualitative data, statistical significance is not discussed

The word most frequently associated with engineering was 'cars', mentioned by 13% of all respondents. Females were twice as likely to mention cars as males and 'non-engineers' were more than three times as likely as 'engineers' to mention them. Within the category 'engineer', females were more inclined to mention cars than were males, following the pattern for females and males in general. However, this finding should be interpreted with caution, due to the very small number of females in the category 'engineer'. Amongst the males, 'non-engineers' were twice as likely as 'engineers' to mention cars, contributing to the more marked difference between 'engineers' and 'non-engineers' than that between males and females.

The word second most often associated with engineering was 'machines/machinery', mentioned by 11% of all respondents. Females were almost twice as likely to mention machines as males and 'non-engineers' were four times as likely as 'engineers' to mention them. Within the category 'engineer', no females mentioned machines, contradicting the pattern for males and females in general. Amongst the males, 'non-engineers' were twice as likely as 'engineers' to mention machines, contributing to the more marked difference between 'engineers' and 'non-engineers' than that between males and females.

The word third most often associated with engineering was 'fixing' (8% of all respondents). This was mentioned by males and females, and by 'engineers' and 'non-engineers' in equal proportions. However, within the 'engineers' category, all who mentioned fixing were male. Fourth was 'mechanics', mentioned by 7% of respondents and by males and females in equal proportions, although within the 'engineers' category, females were more likely to mention it. In fifth place was 'engines', mentioned by 5% of respondents, although males were more likely to mention it than females and male 'engineers' more likely to mention it than female 'engineers'.

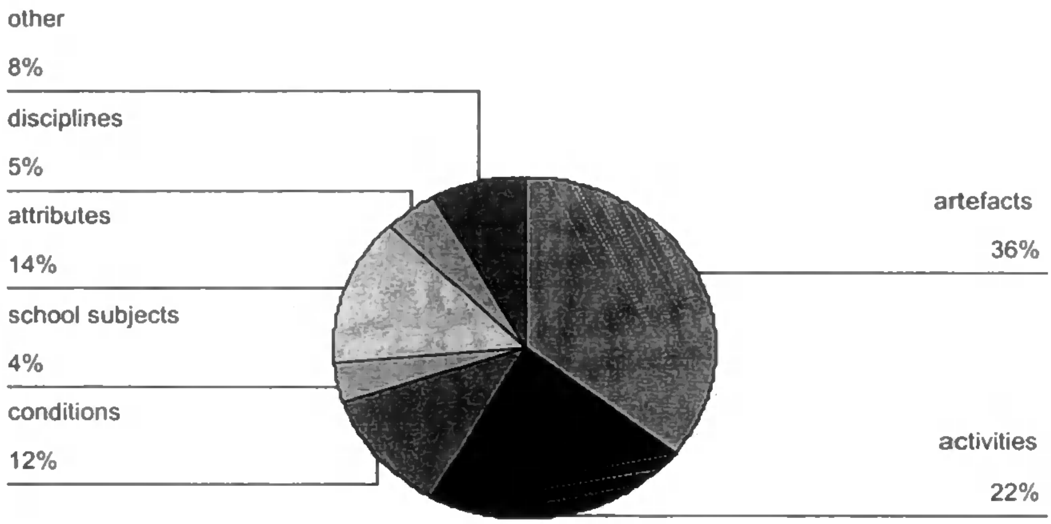
Categories of words associated with engineering

Categorisation scheme 1

A second step was to categorise the words after examining them for key themes and concepts. The words were coded into seven categories and Illustration C below summarises the frequencies for each category. The largest category, *artefacts* (36% of respondents), contains words associated with engineering artefacts, objects and products, such as 'cars', 'aeroplanes', 'bridges' and 'computers'. The second largest category, *activities* (22% of respondents), contains words referring to specific engineering work activities, for example, 'making things', 'building things', 'problem-solving', 'designing' and so on. The third largest category, *attributes* (14% of respondents) contains words relating to attributes of the engineer as a person, in terms of gender, personality, appearance, characteristics and specific work role. This category consists mainly of the word 'mechanic', but also includes words such as 'scientist', 'male', 'boring', 'expert', 'bald' and 'imaginative'. The fourth largest category, *conditions* (12% of respondents), contains words relating to working conditions and environments, such as 'factory work', 'manual work', 'technical', 'challenging', 'industrial' and 'dirty'. In fifth place, the category *disciplines* (5% of respondents) contains named engineering disciplines, such as civil, electronic, mechanical and aeronautical engineering. In sixth place, the smallest category, *school subjects* (4% of respondents) contains engineering-related school subjects and courses, such as maths, science, physics, technology and GNVQ engineering. Finally, the category *other* (8% of respondents) contains words mentioned very infrequently, which did not readily fit into any of the previous categories.

Illustration C : Categories of words associated with engineering

All respondents n=557



An analysis of Chi-square statistics indicated that the students' perceptions of engineering varied both by gender and intention to pursue engineering as a career (see Table 34 below for significance levels). Although 'artefacts' was the most frequent word category for both sexes, girls were much more likely than boys to offer words in this category (41% and 29% respectively). Girls were also rather more likely than boys to mention words relating to attributes of the engineer, and also more likely than boys to name specific engineering disciplines, such as 'civil engineering', or 'mechanical engineering'. Boys on the other hand, were much more likely than girls to mention engineering activities, and to a lesser extent, working conditions. Boys were also more than twice as likely as girls to offer 'other' words that could not be allocated to any of these categories (12% of boys, compared with 5% of girls). This difference suggests perhaps, that boys have a wider perception or knowledge than girls of what engineering is.

When comparing 'engineers' and 'non-engineers', it was found that 'non-engineers' were more than twice as likely as 'engineers' to mention artefacts (40% and 17% respectively). 'Non-engineers' were also slightly more likely than 'engineers' to mention school subjects.

'Engineers', on the other hand, were much more likely than 'non-engineers' to mention activities (the most frequent category for 'engineers' at 29%), disciplines and, to a lesser extent, working conditions. 'Engineers' were more than twice as likely as 'non-engineers' to mention words that could not be allocated to any of these categories (14% of 'engineers', compared with 7% of 'non-engineers'). Again, this suggests, predictably, that those students considering engineering as a career have a broader perception and knowledge of what engineering entails than those not considering it.

Although within the category 'engineer' comparisons between male and female 'engineers' were difficult to make, due to the small number of females considering engineering, particular differences are worthy of note. The male 'engineers' were much more likely than the female 'engineers' to mention artefacts. This finding is perhaps surprising, since the comparison of all males and females in the sample had shown the opposite trend – that females were much more likely to mention artefacts than males. In keeping with the pattern found between the males and females generally, male 'engineers' were rather more likely than female 'engineers' to mention working conditions and 'other' words that could not be allocated to the existing categories. In common with females generally, the female 'engineers' were more likely than male engineers to mention images of the engineer (although rather more so than females in general), school subjects and engineering disciplines. Engineering activities were mentioned in similar proportions by both male and female 'engineers', suggesting a shared awareness within this group of the nature of engineering work. This finding differed from that of males and females generally, in that males had been much more likely than females to mention it.

Table 34: Categories of words associated with engineering. Percentages for all students and for sub-groups

		Males	Females	All
Artefacts	all	29.3	41.1	
	engineers	19.2	9.1	17.4
	non-engineers	33.5	43.1	39.5
Activities	all	26.6	19.2	
	engineers	30.1	27.3	29.1
	non-engineers	23.1	18.2	20.0
Conditions	all	13.1	10.3	
	engineers	13.7	9.1	14.0
	non-engineers	12.7	10.6	11.3
School subjects	all	3.1	4.8	
	engineers	2.7	9.1	3.5
	non-engineers	3.5	4.4	4.0
Attributes	all	13.1	14.7	
	engineers	12.3	27.3	14.0
	non-engineers	14.5	14.2	14.4
Disciplines	all	3.1	5.5	
	engineers	6.8	9.1	8.1
	non-engineers	1.7	5.1	4.0
Other	all	11.6	4.5	
	engineers	15.1	9.1	14.0
	non-engineers	11.0	4.4	6.9

Note: For males/females Chi-square = 21.657, df=6, p=0.001. For engineers/non-engineers, Chi-square = 20.230, df=6, p=0.003

Categorisation scheme 2

Categorisation scheme 1 provided categories that were fairly abstract, therefore the words were categorised a second time to reflect some of the more concrete aspects of the respondents' perceptions of engineering. To develop these categories, all of the words each respondent had written were examined to elicit an overall perception of engineering.

Where respondents had written several words that were unconnected to each other, only their *first* word was categorised. Fourteen categories emerged from the data, the frequencies for which are displayed in table 35 below.

Table 35: Categories of words associated with engineering. Percentages for all respondents and various sub-groups

Category	All (n=464)	Males (n=212)	Females (n=247)	Engineers (n=72)	Non-engineers (n=377)
vehicles	18.1	13.2	22.3	8.3	20.2
manual work	15.1	14.6	15.4	15.3	15.6
machinery	13.4	9.9	16.6	5.6	15.1
professional work	11.0	12.7	8.9	22.2	8.5
fixing/repairing/	8.2	9.9	6.9	8.3	8.0
engines	6.7	7.5	6.1	4.2	7.2
building/making	4.5	7.5	2.0	8.3	8.0
designing	4.1	5.2	3.2	8.3	3.4
male	3.7	0.5	6.5	0	4.2
bridges/structures	3.4	5.7	1.2	4.2	2.9
tools	3.2	4.2	2.4	1.4	3.7
both professional <u>and</u> manual work	2.4	0.9	3.6	5.6	1.6
appearance	1.7	1.9	1.6	1.4	1.9
other	4.5	6.1	3.2	6.9	4.2

Note: the difference between males and females was significant at less than 0.0001 (Chi-square statistic = 45.621, df = 13). The difference between 'engineers' and 'non-engineers' was also significant at less than 0.0001 (Chi-square statistic = 36.631, df = 13), however 32.1% of cells had an expected count of less than 5, due to the small size of the 'engineers' group and therefore the data should be treated with caution.

In this second categorisation, the most popular category was vehicles, mentioned by 18% of respondents as a whole (84 students), although females and 'non-engineers' were much more likely to mention vehicles than males or 'engineers'. The polarisation in this particular category was more marked between the 'engineers' and 'non-engineers' than it was between males and females. 'Non-engineers' were more than twice as likely as 'engineers' to mention vehicles, whereas females were less than twice as likely to mention them as males. The second most popular category was 'manual work', mentioned by 15% of respondents (70 students). Within the category, there were no differences between males and females or between 'engineers' and 'non-engineers'. In third place was 'machinery', mentioned by 13% of respondents, although females mentioned words in this category nearly twice as often as males and 'non-engineers' three times as often as engineers. Professional work came to mind for 11% of the respondents, although males were more likely to mention it than females. 'Engineers', for whom professional work was the most popular category (mentioned by 22%), were almost three times as likely to mention it as 'non-engineers'. Words in the 'fixing/repairing/mending' category were mentioned by 8% of respondents, although more often by males than females, whereas 'engineers' and 'non-engineers' mentioned them in more or less equal proportions. Engines were mentioned by 7% of respondents, and by boys and girls in roughly equal proportions. 'Non-engineers' were slightly more likely than 'engineers' to mention them. Building/making things was mentioned by 5% of respondents, but males were more than twice as likely to mention it as females and 'engineers' more than twice as likely to mention it as 'non-engineers'. 'Designing' was mentioned by 4% of respondents, slightly more often by males than by females, but more than twice as often by 'engineers' than 'non-engineers'. The words 'male', 'males' and 'men' were mentioned by 4% of respondents (17 students). However, all but one of these respondents was female and all were 'non-engineers'. 'Bridges/structures' were mentioned by 3% of respondents, but four times as often by males as females and almost twice as often by 'engineers' as 'non-engineers'. Tools were brought to mind for 3% - more often for males than females, and more often for 'non-engineers' than 'engineers'. Females were more inclined than males to view engineering as both a professional *and* manual occupation and 'engineers' more likely to do this than 'non-engineers'. Finally, a very small percentage (2%) mentioned words associated with the way engineers look. There were no differences between males and females or between 'engineers' and 'non-engineers' in this category.

Within the 'engineers' category males and females were compared. However, the larger number of categories in this second scheme resulted in smaller cell counts, so any comparisons between the two groups must be tentative. Table 36 summarises the frequencies of each of the words for male and female 'engineers'.

Table 36: Categories of words associated with engineering for male and female 'engineers'. Frequencies

Category	Male 'engineers'	Female 'engineers'
Professional work	14	1
manual, 'hands on' work	10	1
designing	6	0
fixing/repairing/mending	6	0
building/constructing/making	5	1
vehicles	5	1
machinery	4	0
engines	3	0
bridges/structures	3	0
both professional and manual work	1	3
tools	1	0
appearance/clothing	0	1
other	4	1
TOTALS	62	9

The table shows that the most popular category for 'engineers' as a whole was 'professional work', but that almost all of those who said this were male. Similarly, 'manual hands on work', the second most frequent category almost entirely comprised the male 'engineers'. On this item, there were only nine responding female 'engineers' and three of these mentioned words that constructed engineering as both professional *and* manual work. The fact that professional work and manual work were the two most frequently mentioned categories suggests that two very different images of engineering co-exist amongst these students.

Summary – words associated with engineering

For categorisation scheme 1, respondents as a whole were most likely to associate engineering with artefacts or products, but females more so than males. Respondents were second most likely to think of specific activities that engineers do, but males more often than females. They were third most likely to conjure up certain attributes of the stereotypical engineer as a person, i.e. 'male', 'boring', 'scientist' and so on, but the females were more likely to do this than the males. In general the differences between 'engineers' and 'non-engineers' mirrored those between males and females. In all but one of the word categories, the two sets of groups were positioned in relative terms so that the males' responses were similar to the 'engineers' and the females' to the 'non-engineers'. In each case, females and 'engineers' were the two most diametrically opposed groups. The one exception to this was that females and 'engineers' were more likely than males and 'non-engineers' to identify specific engineering disciplines.

When males and females were analysed separately within the category 'engineer', it was found that female 'engineers' were like females in general in some respects, but like male engineers in others. Like females generally, female engineers mentioned attributes of the engineer, school subjects and engineering disciplines more frequently than male engineers. However, unlike females generally, female engineers were less likely than their male counterparts to mention artefacts. Also, the female engineers were just as likely to mention engineering activities as their male counterparts, whereas females in general had mentioned them less often than males. Inferences based on these data can only be tentative, however, due to the small number of female 'engineers' in the sample.

Categorisation scheme 2 showed that respondents as a whole were most likely to associate engineering with vehicles, manual work and machinery. However, analyses by gender and intention to consider a career in engineering revealed that males, females, 'engineers' and 'non-engineers' differed in some of their perceptions. Table 37 summarises these perceptions by comparing the three words most frequently associated with engineering for all respondents and for males, females and 'engineers'. The table shows that 'engineers' associated engineering first and foremost with professional work, 'non-engineers' and females associated it with vehicles, and males associated it with manual work.

Table 37: The three words most frequently associated with engineering for all respondents and sub-groups of students

	1st word	2nd word	3rd word
All	vehicles	manual work	machinery
Males	manual work	vehicles	machinery
Females	vehicles	machinery	manual work
Engineers	professional work	manual work	*

*For 'engineers' there were four words in joint 3rd place.

Attributes required by engineers

A second way of measuring students' perceptions of engineers and knowledge about what engineering might entail was to explore their beliefs about which are the most important attributes they thought an engineer should possess. Respondents were presented with a list of thirteen attributes, some of which were derived from consultations with professional engineers about the skills expected of a professional engineer and others from popular stereotypes of the typical engineer. From these, respondents were asked to choose and rank in order of importance the five attributes they considered to be most needed by engineers.

Table 38 displays the frequencies for the most important attribute (that is, the attribute ranked by respondents as '1' on their questionnaires). The table shows that the most frequently chosen attribute was 'practical skills, chosen by two-thirds (32%) of respondents. In second place was 'scientific knowledge' (20% of respondents), in joint third place were 'able to manage people and projects' (11%) and 'mathematical knowledge' (11%) and in fifth place was physical strength (8%). The table displays these thirteen attributes in descending order of popularity.

Table 38: Most important attribute required by engineers. All respondents.

Attribute	% n=531
1. Practical skills	32.4
2. Scientific knowledge	20.2
3. Able to manage people and projects	11.3
4. Mathematical knowledge	10.9
5. Physical strength	8.1
6. Good imagination	5.3
7. Career-minded	3.2
8. Verbal communication skills	2.8
9. = Creativity	2.1
Enjoy working with other people	2.1
10. Respects the environment	1.5
11. Interested in people	0.2
12. Written skills	0.0

Crosstabulating by gender revealed no statistically significant association between gender and perceptions of the attributes required by engineers. It is worth mentioning however, that the biggest difference in their views was on the attribute 'verbal communication skills', which males believed a more important attribute for engineers than females (5% and 1% respectively). There was also no statistically significant association between intention towards engineering and perceptions of attributes. However it is worthy of note that the 'non-engineers' were rather more likely than the 'engineers' to believe engineers require 'practical skills' (34% and 25% respectively) and 'physical strength' (9% and 5% respectively). The 'engineers' were more likely than the 'non-engineers' to believe that engineers need 'verbal communication skills' (8% and 2% respectively).

Overall the data indicates that a strong image of engineering as a practical occupation requiring scientific and mathematical knowledge is held amongst this sample of young people. It is also worth noting that 'physical strength' was thought to be a necessary attribute by a fairly high proportion of respondents, despite the fact that physical strength would not be a necessary requirement for most professional engineering roles. This could indicate that many respondents think of engineering primarily as a manual occupation, rather than an academic one. The most frequently chosen attributes are also those that have traditionally been possessed by males and in this sense, it can be argued that this data reflects the perception of engineering as a masculine occupation.

Attitudes towards engineering as a career

The data discussed in this section of the Chapter set out to examine the kinds of attitudes and beliefs that the students might hold towards engineering as a career. It aimed to find out whether attitudes were generally positive, negative or 'indifferent' and whether this varied by gender and intentions towards engineering. In order to achieve this, respondents were presented with seventeen statements about engineering as a career and asked to indicate their agreement or disagreement with them. The statements were derived from background literature and were designed to test a number of propositions about engineering and its negative image. To minimise the incidence of 'response sets' (Neuman, 1994: 155) or response bias, some of the statements were expressed in positive terms and some in negative terms (although classifying these statements as positive or negative is not unproblematic, as shall be seen later). The hypotheses tested were: that engineering is perceived as a male-dominated occupation (statements 3, 6 and 11), that it is not seen as an interesting or relevant career (statements 2 and 12), that it is seen as a 'boring' occupation (statement 8), that it is considered an un-academic occupation (statements 1 and 10), that women in engineering face a number of difficulties (statements 9, 13, 15 and 17), that engineers are 'asocial' (statement 5), that engineering is not a 'people' job (statement 14) and that engineering degree courses are intense, leaving less time for leisure than other courses (statement 16).

A five-point Likert scale was used for each statement, providing the answer categories 'strongly agree', 'agree', 'not sure', 'disagree' or 'strongly disagree'. The percentages of responses in each category for all of the statements are presented in table 39 below. The table shows that there was a high degree of ambivalence about the statements, as the modal answer category for eleven out of the seventeen statements was 'not sure'. Furthermore, even when frequencies in the two categories either side of 'not sure' are combined, 'not sure' remains the largest category for ten of the seventeen statements. Of the remaining seven statements, the majority of respondents agreed with four and disagreed with three. Respondents agreed or strongly agreed that 'today more and more women are becoming engineers' (50% of respondents), that 'a woman going into engineering would have to cope with hostile remarks from the men' (40%), that 'men are more likely to become engineers than women' (60%) and that 'engineering is more about working with tools and objects than working with people' (46%). They disagreed or strongly disagreed that 'people who become engineers are generally not very interested in people' (59%), that 'engineering is a man's world' (57%) and that 'the prospect of working in an all-male environment is off-putting' (46%).

Table 39: Attitudes towards engineering (all respondents). Percentages.

	% Strongly Agree	% Agree	% Not Sure	% Disagree	% Strongly Disagree
1. Engineering is one of the most difficult careers to get into	2.3	12.7	59.2	23.1	2.8
2. Engineering is a really interesting career	5.0	24.1	47.0	17.7	6.1
3. These days, more and more women are becoming engineers	6.6	43.0	42.0	5.9	2.4
4. Engineering is a career which requires a full-time career commitment	5.4	36.6	49.4	8.5	0.2
5. People who become engineers are generally not very interested in people	1.4	4.9	35.2	43.2	15.3
6. Engineering is a man's world	5.5	13.0	24.3	32.8	24.4
7. Training to become an engineer is no more difficult than training to become a lawyer or a teacher	3.0	21.7	55.0	15.8	4.5
8. Engineering seems boring compared to other jobs	6.1	22.0	36.9	28.4	6.6

Table 39 (continued): Attitudes towards engineering (all respondents). Percentages.

	% Strongly Agree	% Agree	% Not Sure	% Disagree	% Strongly Disagree
9. A woman going into engineering would have to cope with hostile remarks from the men	8.0	31.6	36.1	18.2	6.1
10. You need to be clever to become an engineer	5.4	35.3	43.9	13.5	1.9
11. Men are far more likely to take up careers in engineering than women are	10.2	49.6	30.5	8.5	1.2
12. In today's technological world, engineering is the career of the future	6.1	22.5	58.2	11.3	1.9
13. In engineering you can't afford to take a career break	2.6	4.7	67.5	23.1	2.1
14. Engineering is more about working with tools and objects than working with people	6.6	39.7	34.5	18.4	0.9
15. The prospect of working in a nearly all-male environment is off-putting	2.9	16.6	34.1	37.4	8.8
16. At university, science and technical courses leave you with less leisure time than other courses	1.6	12.3	67.5	17.5	1.0
17. Women engineers can easily combine their career with having a family	3.8	23.1	62.2	9.0	1.9

In view of the high level of ambivalence evident in the clustering of responses around the middle 'not sure' category, one-sample t-tests were performed, to find out how far the mean ratings of each statement differed significantly from this 'not sure' category (test value = 3). Table 40 below shows the mean ratings of the attitude statements, the direction of the attitudes (i.e. agree/disagree) and their significance levels. The t- tests found that the responses to thirteen of the seventeen statements differed significantly from 'not sure'. Four statements did not differ from 'not sure'. These were: 1) that engineering is boring, 2) that it leaves you with less leisure time than other courses in HE, 3) that training is no more difficult than that for lawyers or teachers, and 4) that engineering is a really interesting career. Of the remaining thirteen, the statement most significantly different from not sure in the 'disagree' direction was 'people who become engineers are generally not very interested in people'. The statement most significantly different from not sure in the 'agree' direction was that 'men are far more likely to take up careers in engineering than women are'.

Table 40: Mean ratings of attitude statements (all respondents)

Statement	Mean rating	Difference from 'not sure' (3), (t-value)	Direction of attitude (agree/ disagree)	Significance Level
People who become engineers are generally not very interested in people	3.66	18.823	disagree	.000
Engineering is a man's world	3.58	11.993	disagree	.000
The prospect of working in an all male environment is off-putting	3.33	8.216	disagree	.000
In engineering you can't afford to take a career break	3.17	6.311	disagree	.000
Engineering is one of the most difficult careers to get into	3.11	3.719	disagree	.000
Engineering seems boring compared to other jobs	3.07	1.787	not sure	NS
At University, science and technical courses leave you with less leisure time than other courses	3.04	1.578	not sure	NS
Training to become an engineer is no more difficult than training to become a lawyer or a teacher	2.97	-.909	not sure	NS
Engineering is a really interesting career	2.96	-1.122	not sure	NS
A woman going into engineering would have to cope with hostile remarks from the men	2.83	-4.059	agree	.000
Women engineers can easily combine their career with having a family	2.82	-5.956	agree	.000
In today's technological world, engineering is the career of the future	2.80	-5.976	agree	.000
You need to be clever to become an engineer	2.71	-8.249	agree	.000
Engineering is more about working with tools and objects than working with people	2.67	-8.951	agree	.000

Table 40 (continued): Mean ratings of attitude statements (all respondents)

Statement	Mean rating	Difference from 'not sure' (3), (t-value)	Direction of attitude (agree/ disagree)	Significance Level
Engineering is a career which requires a full-time career commitment	2.62	-12.751	agree	.000
These days, more and more women are becoming engineers	2.55	-13.551	agree	.000
Men are far more likely to take up careers in engineering than women are	2.41	-17.089	agree	.000

To facilitate comparison of sub-groups using cross-tabulations, the variables for the statements were re-coded, collapsing the two agree and disagree categories either side of the middle 'not sure' category to make three categories in total: 'agree', 'disagree' and 'not sure'. Table 41 below shows the percentages in these answer categories for all respondents, as well as separately for the sub-groups of males and females and 'engineers' and 'non-engineers'. Where differences between the sub-groups reached statistical significance, these are indicated in the table by asterisks, where * = $p<0.05$, ** = $p<0.01$, *** = $p<0.001$ (see also note to Table 41).

Table 41: Responses to attitude statements. All respondents and cross-tabulations of sub groups

Attitude statement	Respondent group	% agree	% disagree	% not sure
1. engineering is difficult to get into	all (n=568)	14.8	25.7	59.5
	males (n=259)	19.3	29.7	51.0
	females (n=309)	11.0	22.3	66.7***
	engineers (n=86)	29.1	40.7	30.2
	non-engineers (n=467)	12.4	23.1	64.5***
2. engineering is an interesting career	all (n=568)	28.9	24.1	47.0
	males (260)	43.1	16.2	40.8
	females (308)	16.9	30.8	52.3***
	engineers (n=88)	75.0	4.5	20.5
	non-engineers (n=465)	18.5	28.6	52.9***

Table 41 (continued): Responses to attitude statements. All respondents and cross-tabulations of sub groups

Attitude statement	Respondent group	% agree	% disagree	% not sure
3. today, more women are becoming engineers	all (n=566)	49.6	8.5	41.9
	males (259)	43.6	11.2	45.2
	females (307)	54.7	6.2	39.1*
	engineers (n=87)	55.2	9.2	35.6
	non-engineers (n=464)	47.8	8.4	43.8
4. engineering requires a full-time career commitment	all (n=569)	41.7	8.6	49.7
	males (261)	52.1	8.0	39.8
	females (308)	32.8	9.1	58.1***
	engineers (n=88)	61.4	8.0	30.7
	non-engineers (n=466)	37.6	8.6	53.9***
5. engineers are not interested in people	all (568)	6.3	58.3	35.4
	males (260)	10.4	55.4	34.2
	females (308)	2.9	60.7	36.4**
	engineers (n=87)	6.9	71.3	21.8
	non-engineers (n=466)	6.4	55.2	38.4*
6. engineering is a man's world	all (569)	18.6	57.3	24.1
	males (260)	21.2	50.0	28.8
	females (309)	16.5	63.4	20.1**
	engineers (n=88)	20.5	62.5	17.0
	non-engineers (n=466)	18.0	55.6	26.4
7. training to become an engineer no more difficult than lawyer or teacher	all (569)	24.6	20.2	55.2
	males (260)	24.6	23.8	51.5
	females (309)	24.6	17.2	58.3
	engineers (n=88)	36.4	23.9	39.8
	non-engineers (n=466)	21.9	20.6	57.5**
8. engineering seems boring compared to other jobs	all (566)	28.3	35.2	36.6
	males (259)	18.5	44.8	36.7
	females (307)	36.5	27.0	36.5***
	engineers (n=86)	4.7	75.6	19.8
	non-engineers (n=465)	33.5	25.8	40.6***

Table 41 (continued): Responses to attitude statements. All respondents and cross-tabulations of sub groups

Attitude statement	Respondent group	% agree	% disagree	% not sure
9. a woman going into engineering would have to cope with hostile remarks from men	all (568)	40.0	24.3	35.7
	males (260)	38.1	25.4	36.5
	females (308)	41.6	23.4	35.1
	engineers (n=88)	37.5	34.1	28.4
	non-engineers (n=465)	39.8	22.4	37.8
10. you need to be clever to become an engineer	all (565)	40.5	15.4	44.1
	males (258)	43.4	18.2	38.4
	females (307)	38.1	13.0	48.9*
	engineers (n=86)	60.5	16.3	23.3
	non-engineers (n=463)	36.5	14.5	49.0***
11. men are more likely to become engineers than are women	all (569)	60.1	9.5	30.4
	males (260)	58.1	8.1	33.8
	females (309)	61.8	10.7	27.5
	engineers (n=87)	60.9	11.5	27.6
	non-engineers (n=467)	58.9	9.6	31.5
12. engineering is the career of the future	all (569)	28.5	13.2	58.3
	males (260)	36.2	15.4	48.5
	females (309)	22.0	11.3	66.7***
	engineers (n=87)	54.0	12.6	33.3
	non-engineers (n=467)	23.1	13.1	63.8***
13. in engineering you can't afford to take a career break	all (568)	7.4	25.0	67.6
	males (260)	11.9	24.6	63.5
	females (308)	3.6	25.3	71.1**
	engineers (n=87)	16.1	31.0	52.9
	non-engineers (n=466)	5.8	23.8	70.4***
14. engineering is more about working with tools and objects than working with people	all (569)	46.2	19.2	34.6
	males (260)	39.2	26.2	34.6
	females (309)	52.1	13.3	34.6***
	engineers (n=88)	35.2	42.0	22.7
	non-engineers (n=466)	48.7	13.9	37.3***

Table 41 (continued): Responses to attitude statements. All respondents and cross-tabulations of sub groups

Attitude statement	Respondent group	% agree	% disagree	% not sure
15. the prospect of working in a nearly all-male environment is off-putting	all (569)	19.9	46.0	34.1
	males (260)	20.4	40.0	39.6
	females (309)	19.4	51.1	29.4*
	engineers (n=88)	20.5	53.4	26.1
	non-engineers (n=466)	19.7	44.0	36.3
16. at university, science and technology courses leave less leisure time than other	all (568)	13.9	18.7	67.4
	males (259)	17.8	18.9	63.3
	females (309)	10.7	18.4	70.9*
	engineers (n=88)	27.3	22.7	50.0
	non-engineers (n=465)	11.8	17.0	71.2***
17. women engineers can easily combine their career with having a family	all (568)	26.9	10.9	62.1
	males (260)	27.7	14.6	57.7
	females (308)	26.3	7.8	65.9*
	engineers (n=88)	35.2	15.9	48.9
	non-engineers (n=465)	24.7	10.3	64.9*

Note: Chi-square significance indicated by the following: * = $p<0.05$, ** = $p<0.01$, *** = $p<0.001$

Discussion of findings on each statement

The findings for each of the seventeen statements presented in Table 41 are now described more discursively in turn below:

1. '*Engineering is difficult to get into*'

This statement resulted in a high level of uncertainty. The majority of all respondents (60%) said they were not sure whether engineering is difficult to get into. Of the remaining respondents, 26% disagreed, and 15% agreed. The ambiguousness of these responses suggests that perhaps the statement itself was too vague to be interpreted in any uniform manner and would need to be more concretely operationalised in any future project. Crosstabulations and analysis of Chi-square revealed a statistically significant association between gender and attitude towards this statement (p=<0.001). Although the majority of both sexes were uncertain, females were more so, with two-thirds (67%) of females saying they were not sure, compared with just over half of the males (51%). Males were more likely than females to both agree *and* to disagree with the statement. Almost one-third (30%) of males disagreed that engineering is difficult to get into, compared with less than one-quarter (22%) of females, whilst 19% of males agreed, compared with 11% of females. Crosstabulating by the intention towards engineering variable revealed that 'engineers' and 'non-engineers' also differed in their responses to the statement. 'Engineers' both agreed *and* disagreed with the statement more often than 'non-engineers'. They were almost twice as likely as non-engineers to *disagree* that engineering is difficult to get into (41% and 23% respectively) and were also more than twice as likely as non-engineers to *agree* with the statement (29% and 12% respectively). Almost two thirds (65%) of 'non-engineers' were not sure whether engineering is difficult to get into, compared with less than one third (30%) of 'engineers' (p=<0.001).

2. '*Engineering is an interesting career*'

Almost half of all respondents (47%) were not sure if they thought engineering is an interesting career. This high level of uncertainty in relation to whether engineering is an interesting career or not provides support for the proposition discussed earlier in this Chapter, that there is a widespread lack of awareness amongst young people of what engineering is about. Crosstabulations and analysis of Chi-square revealed that gender had an impact on attitude towards this statement (p=<0.001). Males and females were opposed in their responses. Males were more than twice as likely as females to agree that engineering is an interesting career (43% and 17% respectively), whereas females were almost twice as likely as males to disagree (31% and 16% respectively). Substantial proportions of each sex, more than half of females (52%) and two-fifths of males (41%) said they were not sure. A statistically significant association between intention towards engineering and attitude towards the statement was also found (p=<0.001). As expected, the majority of 'engineers' (75%) agreed that engineering is an interesting career, compared with less than one-fifth of 'non-engineers' (19%). Nonetheless, a substantial proportion - one fifth (21%) of 'engineers' were uncertain, although this proportion is low in comparison to 'non-engineers', just over half of whom (53%) said they were not sure.

3. '*Today, more and more women are becoming engineers*'

Half of all respondents (50%) agreed that today, more and more women are becoming engineers, with the majority of the remaining respondents (42%) saying they were not sure and only 9% disagreeing. This reflects a fairly optimistic view amongst the students about female participation in engineering. Crosstabulating by gender showed a statistically significant association between gender and attitude towards the statement (p=<0.05). Females were more inclined than males to agree with the statement (55% and 44% respectively), perhaps indicating a greater tendency for females to support an 'equal opportunities' view. Small proportions of both sexes disagreed with the statement, but more than one-third of each sex said they were not sure. No statistically significant relationship was found between intention towards engineering and attitude towards the statement. Surprisingly, the 'engineers' were more likely than 'non-engineers' to agree (55% and 48% respectively). Less than 10% of both 'engineers' and 'non-engineers' disagreed with the statement, but more than one-third of each group said they were not sure.

4. '*Engineering requires a full-time career commitment*'

There was a high level of ambivalence about this statement, with half of all respondents (50%) saying they were not sure if engineering requires a full-time career commitment, although the majority of the remaining respondents agreed (42%) with only 9% disagreeing. Crosstabulating by gender revealed that there was a statistically significant association between gender and attitude towards the statement (p=<0.001). Whilst a minority of both sexes disagreed with the statement, more than half of the males (52%) agreed, compared with only one-third of the females (33%), the majority of whom (58%) said they were not sure. Crosstabulations and analysis of Chi-square showed a statistically significant association between positive intentions towards engineering and agreement with the statement. Of all the respondent groups, the 'engineers' were the group most likely to agree that engineering requires a full-time career commitment. Almost two-thirds (61%) of the 'engineers' agreed, compared with only 38% of the 'non-engineers', the majority of whom (54%) were not sure (p=<0.001).

5. '*Engineers are not interested in people*'

More than half of all respondents (58%) disagreed with this statement and most of the remainder said they were not sure (35%), with only 6% agreeing. Crosstabulating by gender revealed some statistically significant differences between the sexes in their responses (p=<0.01). Females were more likely than males to disagree (61% and 55% respectively), but one-third of both sexes said they were not sure. Perhaps surprisingly, males were more likely than females to agree with the statement (10% and 3% respectively), although these were small percentages of students. Crosstabulating by the intention towards engineering variable showed that although the majority of both 'engineers' and 'non-engineers' disagreed, unsurprisingly, 'engineers' were much more likely to disagree, with almost three-quarters of the 'engineers' (71%) disagreeing, compared with just over half (55%) of the non-engineers (p=<0.05).

6. '*Engineering is a man's world*'

More than half of all respondents (57%) disagreed that engineering is a man's world, with about one-quarter (24%) saying they were not sure. Only 19% of respondents agreed with the statement. Crosstabulating by gender showed a statistically significant association between gender and attitude towards the statement (p=<0.01). Although the majority of both sexes disagreed with the statement, females were more likely than males to disagree (63.4% and 50.0% respectively). In contrast, males were more inclined than females to agree with the statement (21% and 17% respectively) and were also more likely than females to say they were not sure (29% and 20% respectively). There was no statistically significant association between intention towards engineering and agreement with the statement. The majority of both 'engineers' and 'non-engineers' disagreed with the statement, although a higher percentage of 'engineers' than 'non-engineers' disagreed (62.5% and 55.6% respectively). A smaller proportion of both groups (approximately one-fifth) agreed, whilst 'non-engineers' were more likely to say they were not sure than were the 'engineers' (26.4% and 17.0% respectively).

7. *'Training to become an engineer is no more difficult than training to become a lawyer or a teacher'*

This statement attracted a high level of ambivalence, with more than half (55%) of respondents saying they were not sure and the rest fairly evenly split between agree and disagree. Again this may be indicative of a general lack of knowledge about what engineering training entails, or it may be that the statement needed to be more concretely operationalised. Crosstabulations revealed no statistically significant differences in responses on the basis of gender. It is worth noting that females were more likely than males to say they were not sure (52% and 58% respectively) and males were more likely than females to disagree (24% and 17% respectively). Crosstabulations showed that intention towards engineering had an impact on the responses to this statement (p=<0.01). The majority of 'non-engineers' were not sure (58%), compared with only about two-fifths (40%) of 'engineers'. The 'engineers' were more likely to agree with the statement than 'non-engineers' (36% and 22% respectively). However, 'engineers' were also slightly more likely to disagree than were 'non-engineers' (24% and 21% respectively).

8. '*Engineering seems boring compared to other jobs*'

More than one-third (37%) of respondents said they were not sure whether engineering seems boring compared to other jobs. Of the remaining respondents, most (35%) were likely to disagree, although more than one-quarter of all respondents (28%) agreed. Crosstabulations showed a statistically significant association between gender and attitude towards this statement (p=<0.001). The sexes were opposed in their responses with 37% of females agreed that engineering seems boring, compared with only 19% of the males. Conversely, the largest proportion (45%) of the males disagreed, compared with only 27% of the females and just over one-third of both sexes said they were not sure. A statistically significant relationship was also found between intention towards engineering and attitude to this statement (p=<0.001). The oppositions between the 'engineers' and 'non-engineers' mirrored those between males and females but were even more polarised. One-third of 'non-engineers' (34%) agreed that engineering seems boring, compared with only 5% of the 'engineers'. Not surprisingly, more than three-quarters (76%) of 'engineers' disagreed with the statement, compared with only one-quarter of 'non-engineers' (26%). Twice as many 'non-engineers' as 'engineers' were not sure (41% and 20% respectively).

9. '*A woman going into engineering would have to cope with hostile remarks from men*'

A substantial minority (40%) of all respondents agreed that a woman going into engineering would have to cope with hostile remarks from men. Of the remaining respondents, most (36%) were not sure, with just under one-quarter (24%) disagreeing. There were no statistically significant differences in responses on the basis of gender. Similarly, there were no significant differences in responses on the basis of intention towards engineering. However, it is worth noting that the 'engineers' were more likely to disagree with the statement than the 'non-engineers' (34% and 22% respectively), which is perhaps indicative of a desire on behalf of those considering it as a career to present engineering in a more positive light.

10. '*You need to be clever to become an engineer*'

A substantial minority of all respondents (44%) were not sure whether you need to be clever to become an engineer, 41% agreed and only 15% disagreed. Gender had an impact upon attitude towards this statement ($p=<0.05$) the most marked differences being that females were more likely than males to say they were not sure (49% and 38% respectively. Intention towards engineering also had an impact on responses to this statement ($p=<0.001$), with the 'engineers' much more likely to agree than the 'non-engineers' (61% compared with 37%).

11. '*Men are more likely to become engineers than are women*'

The majority of respondents as a whole (60%) agreed that men are more likely to become engineers than are women, reflecting a strong consensus that engineering is a male-dominated occupation. However it is worth noting that a fairly high proportion, almost one-third (30%) of the students said they were not sure. There were no statistically significant differences in responses on the basis of gender. Similarly, there were no significant differences in responses on the basis of intention towards engineering.

12. '*Engineering is the career of the future*'

There was a high level of uncertainty about this statement, with more than half (58%) of all respondents saying they were not sure whether engineering is the career of the future. A statistically significant association was found between gender and attitude towards this statement ($p=<0.001$). The majority of both males and females expressed uncertainty about this statement, although females more so than males, with two thirds (67%) of females saying they were not sure, compared with just under half (49%) of the males. Two thirds of males (36%) agreed that engineering is the career of the future, compared with less than one-quarter (22%) of the females. There was also a statistically significant association between intention towards engineering and attitude towards the statement (p=<0.001). Unsurprisingly, more than half (54%) of the 'engineers' agreed that engineering is the career of the future, compared with less than one-quarter (23%) of the 'non-engineers'. A similar minority of both groups disagreed with the statement, whilst 'non-engineers' were twice as likely as 'engineers' to say they were not sure (64% and 33% respectively).

13. '*In engineering you can't afford to take a career break*'

There was a very high level of uncertainty towards this statement, with more than two thirds (68%) of all respondents saying they were not sure, one-quarter (25%) of respondents disagreed and only 7% agreed. There was a statistically significant association between gender and response to this statement (p=< 0.01), the biggest difference between the sexes being that males were more likely than females to agree with the statement (12% and 4% respectively). There was also a statistically significant relationship between intention towards engineering and attitude towards this statement (p=<0.001) with 'engineers' more likely than 'non-engineers' to disagree (31% and 24% respectively). However, 'engineers' were also more likely than 'non-engineers' to *agree* with the statement (16% and 6% respectively).

14. '*Engineering is more about working with tools and objects than working with people*'

A substantial minority of respondents as a whole (46%) agreed with the statement, with more than one-third (35%) saying they were not sure, and only 19% disagreeing. Gender was found to have an impact on attitude to this statement (p=<0.001). Females were more likely than males to agree (52% and 39% respectively) and males were more likely than females to disagree 26% and 13% respectively). Intention towards engineering also had an impact on attitude to this statement (p=<0.001). 'Non-engineers' agreed more than 'engineers' (49% and 35% respectively), whereas 'engineers' were three times as likely as 'non-engineers' to disagree (42% and 14% respectively).

15. '*The prospect of working in a nearly all-male environment is off putting*'

A substantial minority, just under half of all respondents (46%) disagreed with the statement, more than one-third (34%) were not sure and only one-fifth (20%) agreed. There was a statistically significant association between gender and attitude to this statement (p=<0.05). Surprisingly, females were more likely to disagree than males (51% and 40% respectively), indicating that they are more amenable to working in an all male environment than the male students. There was no statistically significant association between intention towards engineering and attitude to the statement. It is worth noting, however, that 'engineers' were more likely to disagree with the statement than 'non-engineers' (53% and 44% respectively), which may suggest that engineering is unattractive to those males who prefer a mixed-sex working environment.

16. '*At university, science and technology courses leave less leisure time than other courses*'

This statement attracted a very high level of uncertainty, with just over two-thirds (67%) of all respondents saying they were not sure. Again this is possibly due to a lack of knowledge amongst the respondents about what engineering courses are like. A slightly higher proportion of respondents disagreed than agreed, although in both cases this was less than one fifth. There was a statistically significant association between gender and attitude to this statement (p=<0.05). Males were more likely to agree with the statement than females (18% and 11% respectively), which indicates they are more likely than females to perceive engineering degrees as demanding. The sexes disagreed in equal proportions, but females were less sure than males. Intention towards engineering also had an impact on attitude to this statement (p=<0.001). 'Engineers' were more than twice as likely as 'non-engineers' to agree (27% and 12% respectively). Interestingly, however, 'engineers' were also more inclined to disagree than 'non-engineers' (23% and 17% respectively).

17. '*Women engineers can easily combine their career with having a family*'

Again, there was a high level of uncertainty in relation to this last statement, with almost two-thirds (62%) of all respondents saying they were not sure. Of the remaining respondents, most (27%) agreed and only 11% disagreed. There was a statistically significant relationship between gender and attitude to this statement (p=<0.05). Although males and females were equally likely to agree with the statement, males were almost twice as likely as females to *disagree* (15% and 8% respectively). This could be indicative of a more 'realistic' attitude on behalf of males about the demands engineering places upon women, or alternatively, it may reflect a conservative attitude towards the idea of women in general, or women with families, working in engineering. There was also a statistically significant relationship between intention towards engineering and attitude to this statement (p=<0.05). 'Engineers' seemed to be less conservative than males in general, with the 'engineers' more likely than 'non-engineers' to agree that women engineers can easily combine their career with having a family (35% and 25% respectively). The 'non-engineers' were markedly more uncertain than 'engineers' (65% and 49% respectively).

Summary of attitude statements

A complex picture emerged from the responses to the attitude statements. In general, there were high levels of uncertainty, particularly towards those statements concerned with the nature of engineering careers. This may be for a number of reasons. First, it could reflect the lack of an adequate knowledge-base in relation to engineering work. Second, it may indicate a difficulty in interpreting the statements, which may have been too ambiguous for respondents to make sense of them. Third, these statements were situated at the end of a rather long questionnaire and there may have been an ambivalence or antipathy about engaging with the issues due to response fatigue, perhaps leading to a tendency to choose the neutral response. It is worth noting that there was some gendering of the 'not sure' responses. In general, females tended to be less sure than males on questions relating to specific aspects of engineering careers and males tended to be less sure than females on questions relating to gender issues.

For respondents as a whole, the hypothesis that engineers are 'asocial' was not supported, since the majority of respondents *disagreed* that people who become engineers are generally not very interested in people. Respondents nonetheless perceived engineering as a job that is more about working with tools and objects than working with people. This may reflect a particular narrow perception of engineering work (manual, hands-on, lower status) and support the hypothesis that engineering is not a 'people' job, which in turn may discourage those young people who want a high level of social contact in their chosen career and/or feel they are not practically-minded or proficient in manipulating tools and objects (especially girls). Most respondents agreed that men are more likely to take up careers in engineering than are women, reflecting an awareness of the traditionally male-dominated nature of the work. However, most respondents disagreed with the (admittedly rather provocative) statement that engineering is a 'man's world'. It is possible that this particular statement was interpreted in different ways and there could be some slippage between the ideas that engineering 'is' a man's world and that it 'ought' not to be. A majority of respondents disagreed that working in an all-male environment is off-putting and agreed that these days more and more women are becoming engineers, reflecting an optimistic and positive view of women's position in engineering. Conversely, however, a majority of respondents agreed with the statement that a woman going into engineering would have to cope with hostile remarks from the men, reflecting support for the hypothesis that engineering is not 'female friendly'.

Positive or negative towards engineering?: Attitude scores

This final portion of data is concerned with exploring the extent to which respondents were generally positive, negative or neutral towards engineering and how this might vary by gender and intention towards engineering.

It was hypothesised that males and 'engineers' would have a more positive attitude towards engineering than females and 'non-engineers'. In order to test these hypotheses, the seventeen attitude statements discussed above were categorised as either positive (statements 2, 3, 7, 10, 12 and 17) or negative (statements 1, 4, 5, 6, 8, 9, 11, 13, 14, 15 and 16). It was decided that a high score would indicate a positive attitude towards engineering and a low score a negative attitude. The variable values of the attitude statements were therefore re-coded so that agreement with positive statements gave a high score and agreement with negative statements gave a low score (positive = 5-1 and negative = 1-5). The maximum score possible was therefore 85 (5 x 17) and the minimum score was 17 (1 x 17). A neutral or 'not sure' score was 51 (3 x 17).

The mean score for all respondents was 52.8, which was close to a neutral score, but towards the 'positive' direction. When the sexes were compared, the mean score for females was 52.7 and for males it was 52.8. Female scores had a narrower range than males, reflecting less extreme attitudes. The lowest score for females was 40 and the highest, 65, whereas the males' scores ranged from 32 to 73. T-tests revealed no significant differences between the means of males and females' attitude scores. Therefore the null hypothesis of no difference between the attitudes of males and females in terms of their positivity or negativity towards engineering was accepted.

The scores of 'engineers' and 'non-engineers' were also compared. The mean score for 'engineers' was 55.9, compared to 52.0 for 'non-engineers'. The t-test revealed a significant difference between the mean attitude scores of those likely and unlikely to consider engineering as a career (equal variances not assumed, p=0.000). Therefore the null hypothesis was rejected. As expected, those likely to consider engineering as a career had more positive attitudes towards engineering than those unlikely to consider it. In view of the high levels of ambiguity in responses to some of the statements, a new variable was computed, removing those statements with 50% or more respondents answering 'not sure' (statements 1, 7, 12, 13, 16 and 17). T-tests were then repeated for gender and intention towards engineering, but did not differ from the above results, with no significant differences between the mean attitude scores of males and females, but a significant difference between the mean scores of those likely and unlikely to consider an engineering career.

Chapter summary and conclusion

This chapter has presented and discussed findings relating to the students' career aspirations, work values, knowledge about engineering, perceptions of engineering and engineers, and their attitudes towards engineering careers. The students' career aspirations conformed to traditional gender patterns, with males over-represented in aspirations to the armed forces, engineering, computer-related work and the emergency services and females over-represented in teaching, entertainment, nursing, animal-related work and child-related work. Engineering was one of the most popular careers aspired to, with 6% of all students making it a firm career choice, although as expected, the majority of these were male. Females were well represented in aspirations to science-based work, but within this category traditional gender divisions emerged. High earnings were the most important 'work value' to the potential 'engineers' and this they shared with males in general, whereas females prioritised self-fulfilment. Most respondents said they knew nothing at all or not much about engineering and females were less likely to say they knew anything about engineering than males. The hypothesis that higher levels of knowledge about engineering are associated with aspirations towards it was supported, although conclusions could not be drawn about the causal direction of this relationship.

This part of the research had set out to explore the general proposition that engineering has a negative image, by finding out what kinds of popular images of engineering were held amongst the students. In particular, it aimed to test the hypothesis that engineering is stereotyped as a masculine occupation and if so, to find out to what extent this might differentially affect females and males in terms of the barriers to their participation in engineering. Word association techniques found that engineering was most often associated with cars, machinery, fixing, mechanics and engines, words that have traditionally carried male connotations. Students considering a career in engineering associated engineering with both professional and manual work, whereas respondents in general tended to associate it with manual work only, which may be a discouraging factor for many students. Overall, there was a high level of uncertainty and indifference in relation to attitude statements about engineering as a career. Where the respondents did hold strong views, they saw engineering as a career in which men were likely to dominate, which demands intellectual ability, a high level of commitment, and involves working with tools and objects more than people. They believed that women are increasingly entering engineering and did not agree that engineering is a 'man's world', although they did believe that women working in engineering would face hostility from men. The next and final chapter will pull together the findings from Chapters 3, 4 and 5 and draw some conclusions in relation to the research hypotheses.

CHAPTER SIX:

Discussion and conclusion

Introduction

This thesis has examined some of the social factors that shape young people's decisions to pursue an engineering career, with particular emphasis on the barriers to female participation in engineering. Whilst there are important and related issues affecting women's entry, retention and progression in engineering careers, this thesis has focused on the first of these – the issues affecting women's *entry* to engineering. It has done this by examining factors affecting the educational and occupational choices and aspirations of girls and boys in upper secondary school. In the relatively recent past, direct sex discrimination, both at school and at work, was seen as the main barrier to female participation in occupations like engineering. Since the mid-1970s, however, equal opportunities legislation has eroded many of the formal mechanisms of discrimination and there has been a move towards a more gender-neutral curriculum, most notably with the introduction of the National Curriculum in 1988. This has opened up more educational opportunities for girls in secondary school, who have been able to show themselves to be more than capable of achieving in subjects that were formerly considered inappropriate for them. Nonetheless, girls continue to drop the physical sciences, technology and mathematics in large numbers once they are no longer compulsory. And whilst it cannot be denied that girls have made rapid gains in education, both in terms of their participation in non-traditional subjects and their achievements in all subjects, it would also be naive to assume any simple relationship between equitable education outcomes and equitable labour markets. Labour market statistics show that women's educational gains have not been matched in employment, where they are still to be found in low status 'female ghettos' (Hanson et. al, 1996, Francis, 1999; Blackmore, 2001).

The problem therefore is not simply that girls do not take science A-levels, as those that do are more likely to go into the medical or biological sciences than the physical sciences or engineering (Thomas, 1990; Glover, 2000). Therefore, in addition to examining the rejection of science and technology as educational subjects, discouraging factors that are specific to engineering as a career also needed to be considered. There are then two critical and related 'filters' for females out of engineering, the first being subject option choices at school, and the second career aspirations and choices. Although choosing to study engineering-related A-levels is not a sufficient condition for progression to an engineering career, boys have a greater likelihood of staying in the science 'pipeline' for longer than girls, by virtue of their greater tendency to pursue these subjects for longer than girls.

Chapter One showed that whereas in the past, women were formally denied opportunities in engineering through sex discrimination, today, the scarcity of women among engineering undergraduates and professionals is believed to be more to do with the self-selective 'avoidance' of such careers by young women, than with any conscious discriminatory practices within the education system or the labour market (Stolte-Heiskanen, 1991: 43; Equal Opportunities Commission, 2002). In today's 'gender equal' society, the emphasis of policy initiatives has accordingly changed from one of women's *exclusion* to their 'self-exclusion' from engineering careers, mainly through their educational and career 'choices'. The 'problematic' attitudes of girls and women towards mathematics, the physical sciences, computing and technology are now perceived by many to be the main problem (Whitehead, 1996) with much attention focusing on the fact that girls tend to drop the physical sciences and technology in post-compulsory education. Many lament this way of conceptualising the issue, blaming it in part, on a feminist 'backlash', whereby gender inequality has become a private, rather than collective experience (Ward, 2003; Walter, 2003). It certainly seems clear that there has been a shift in mainstream thought from conceptualising female exclusion from educational and occupational opportunities in science and technology as a *collective* matter to a private, individual experience, requiring private rather than collective, political solutions. Within academic feminism also, there have been theoretical shifts, most notably, accompanying the 'cultural turn', a change in focus from the material to the *ideological* conditions of female exclusion. In some ways, post-structuralist feminism has mirrored 'mainstream' thought in its preoccupation with analysing the experience of the individual, or 'subject' and a renewed interest in agency. Along with this, there is always the risk of individualism, of assuming that the individual is completely self-determining and 'able to act and think independently of the social structure and its ideologies' (Jones, 1997, cited in Hughes, 2002: 98). However, the best feminist theories strive to bridge the gap between agency and structure, avoiding individualism and voluntarism on the one hand, and determinism and an over-emphasis on social structure on the other.

Chapter One showed that perhaps the most widely used explanation for female 'avoidance' of the physical sciences and technology has been the argument that these disciplines, both as educational subjects and as occupations, are sex-stereotyped, in the sense that they are considered more appropriate for males than for females. There is a wealth of evidence to show that, as young people grow up, they are channelled into activities considered appropriate for their sex, and their gender socialisation results in sex-differentiated values, preferences, attitudes and occupational identities. This process then not only reproduces, but is also reproduced by, an institutionalised sexual division of labour in the wider society, which acts to structure and constrain the beliefs, expectations and choices of individuals within the given culture. Thus, it has been argued that the sex-stereotyping of the physical sciences, technology and mathematics as appropriate for males, causes many girls to opt out of these subjects early, blocking their opportunities to careers in these areas. In the light of this theory, most strategies and initiatives to increase women's participation in science and technology have concentrated on changing girls' attitudes and encouraging them to choose from a wider range of educational and occupational options. This approach is embodied in the Equal Opportunities Commission's current campaign *What's stopping you*, which aims to encourage young people 'to consider all the available subject choices and career options, and not to limit their opportunities because of their sex' (EOC, 2001).

The theory that young people's sex-stereotyped attitudes are to blame for their gendered educational and occupational choices has, however, been challenged on a number of grounds. One of the limitations of this explanation is its individualism. It over-emphasises the role of agency by individualising choice, playing down the role of wider social structures such as education systems and the institutions of science and technology, where 'hidden' forms of discrimination may be operating to disadvantage girls and women. This means that the question becomes "what is wrong with young people?", as opposed to "what is wrong with engineering?". There is then a tendency to blame girls and women for not taking up the opportunities open to them, and to view them as the ones primarily responsible for change (Kelly, 1987; Henwood, 1996; Glover, 2000). The argument that young people are straightforwardly socialised into gendered occupational identities has also been criticised as an unsatisfactory and at best, partial, explanation of female avoidance of science and technology. One reason for this is that the theory can be too deterministic and lacks a theory of agency in that it cannot account for exceptions to the rule, that is, those women who *do* choose to enter engineering and other traditionally 'masculine' occupations. Many feminists have also pointed out this kind of social determinism can also lead to conservative attitudes, such as accepting gender differences as 'natural', or viewing the sexes in rather complementary, 'different but equal', positions (Connell, 1987; Hollway, 1992). For feminists, this explanation is not acceptable, as it too easily justifies the unequal positions held by the sexes, failing to recognise the hierarchical nature of gender relations and the role of power relations between the sexes. In this theory there has also been a tendency to view gender in binary terms, and to conceptualise men and women as two homogeneous groups. This cannot account for the multiple forms of femininity and masculinity and the flexible, dynamic nature of gender (Wajcman, 1991; Gill and Grint, 1995; Webster, 1996; Martin, 1999).

The research presented here set out to investigate the proposition that engineering is considered a masculine occupation, and to critically examine the idea that sex-stereotyped attitudes are to blame for girls' avoidance of the physical sciences and technology at school, in higher education, and ultimately, for women's under-representation in these fields of work. What differentiates this study from other research in the area, was that this study examined the issues from the standpoint of young people themselves. Is it the case that young people believe that certain subjects and occupations are more appropriate for one sex than another? How much might their enjoyment of and desire to pursue the physical sciences and engineering be shaped by the stereotyped expectations of others? By what mechanisms are educational and occupational sex-stereotypes perpetuated?

The research examined perceptions, images and constructions of, and choices towards school subject disciplines and engineering careers within the context of upper secondary school. The study focused on 16 and 17-year old students, who had made option choices for further education and were studying these within school sixth forms. It examined their views towards the sciences and engineering through a multi-method approach, using focus group interviews and self-completion questionnaires. Both the qualitative and quantitative approaches set out to test the hypothesis that the physical sciences and mathematics are stereotyped by young people as 'masculine' areas and that, in consequence, these subjects, and engineering as an occupation, would be seen as more appropriate for males than for females. In addition to assessing the proposition that engineering is considered masculine, the research was also interested in identifying other factors that might discourage young people from considering engineering careers. Are other factors interconnected with the masculine image of engineering, and to what extent do these factors have differential, or similar effects on the aspirations and choices of girls and boys?

The next section of this chapter draws together the findings of the qualitative and quantitative research, under three key headings: subject choices, career aspirations and engineering as a career. The chapter then contextualises the findings within existing theory and research and assesses the extent to which the research questions have been answered. The latter part of the Chapter includes some methodological reflections and considers the implications of the findings, before offering some suggestions for future research in this area.

Subject choices

Chapter Three showed that factual data on the subjects that were being studied by focus group participants reflected a normative picture of gender differentiation in the subject choices made (see Appendix III for full list of subjects studied by the focus group participants). Similarly, in Chapter Four, the survey data indicated the same gender patterning of A-level subject choices across the larger sample. Typically, girls were over-represented in English, foreign languages, biology, human sciences, drama and home economics and boys in mathematics, physics, design technology, information technology and business studies. Some subjects, however, were classified in this study as 'gender-neutral', when no more than sixty per cent of either sex were found in them. These were general studies, art, history, geography, sports studies, physical education, media and chemistry. Only two A-level subjects however, truly contained *equal* proportions of males and females, and these were general studies (compulsory in many schools) and geography. These findings are consistent with those of other educational studies (Whyte, 1996; Colley, 1998) and of education statistics on examination results for secondary schools in England (see DfES, 2002). At the aggregate level, then, a pattern of traditionally 'gendered' subject choices was found. This result suggests that at some level, gender is shaping young people's subject choice and a key research question was: by what mechanisms was gender operating to produce this outcome? Was it possible to say, for example, that sex-stereotyping was responsible for the gendered choices? If so, at what level was it operating? Were the students under pressure from others to choose particular pathways thought appropriate for their sex? Certainly, the subjective reasons students gave for their subject choices in the focus groups did not reveal any conscious awareness of pressures to choose particular subjects based on gender, such as being 'channelled' into traditionally feminine or masculine disciplines by parents, teachers or peer group. On the contrary, these choices were seen by the participants to be very much self-determined, a matter of individual preference and abilities, with the most frequently given explanations for participants' choices including personal enjoyment, interest, career value and aptitude in the selected subjects.

If the respondents did not feel coerced into their choices by others, was it the case that they themselves held sex-stereotyped beliefs about different subject disciplines, believing that certain subjects were inappropriate for their sex? The survey results reported in Chapter Four suggested initially that this was not the case. When the respondents were asked about the 'appropriateness' of a list of school subjects for males and females, frequency analysis demonstrated support for gender-equity, with the majority of students responding that all of the subjects, *with the notable exception of engineering*, are equally suited to males and females. However, use of t-tests portrayed a different picture, in that with the exception of history, the students' perceptions of all subjects differed significantly from neutral on the masculine-feminine dimension. Furthermore, the participants' *own* subject choices for their sixth form courses, were, on the whole, sex-traditional. Here then, was an obvious gap between the respondents' beliefs and their behaviour, they did not believe that females were better at some subjects and males at others, and yet they had chosen 'sex-traditional' subjects of study themselves. In the focus groups too, the sex-traditional choices the participants' had themselves made were at odds with the egalitarian views they expressed about the gender-appropriateness of subject disciplines. Most of the students appeared to support the principle of gender equality, speaking a 'discourse of equal opportunities', but simultaneously and less obviously, speaking a discourse of sexual difference in relation to females' and males' aptitudes and preferences, and continuing to make gendered choices themselves. This finding supports those of other studies (see for example, Henwood, 1998; Francis, 2000).

Career aspirations

The contradiction between respondents' equality beliefs and their own gendered choices was also evident when assessing the influence of sex-stereotypes on career aspirations. In the focus group interviews, the participants had expressed predominantly non-stereotypic views towards occupations, but despite this, their own career aspirations tended to conform to those traditionally chosen by their own sex. This 'discrepancy' between conforming to traditional gender roles, whilst expressing the appropriateness of gender equality for 'everyone else' has been found elsewhere (Lightbody and Durndell, 1998). Again, amongst those questionnaire respondents who had definite career intentions, the careers aspired to conformed to a traditional gender pattern. Girls were over-represented in aspirations to jobs relating to teaching, nursing, child-related work, social care and languages, whereas boys were over-represented in their aspirations to engineering, the armed forces, police and emergency services and computer-related work (see Appendix V and Chapter Two). Interestingly, however, girls were over-represented in the category 'science-based work', which 5% of all respondents had chosen, with girls comprising more than half (53%) of this category. However the 'science-based work' category used in this investigation contains a wide variety of occupations, some of which have traditionally attracted females, including nutritionist, food scientist, biologist and environmental chemist. Closer examination revealed that the female respondents in the category were more likely to have chosen these occupations, while the males had chosen traditionally 'masculine' jobs, including marine biologist and physicist (see Appendix V for a full list of jobs in the category 'science-based work').

But how far can these gendered career aspirations be explained by the idea that the students' hold sex-stereotyped beliefs about subject disciplines and jobs, which is the primary assumption underpinning many present initiatives to widen young people's choices? Researchers working on young people's educational and occupational decision-making have shown that the assumption that they have sex-stereotyped beliefs is questionable. Whitehead (1996: 158), for example, found that there was no evidence that female A-level students taking 'feminine' subjects had a more stereotypical view of subjects than those doing 'masculine' subjects. Whitehead concluded that there is no necessary relation between choosing 'sex-appropriate' subjects and holding sex-stereotypical views of subjects, although she did find that boys were more influenced by the stereotypes than the girls. In her study, the boys were more likely to choose sex-appropriate subjects than the girls and those boys choosing exclusively masculine subjects were much more likely to have a stereotyped view of subjects, compared with boys doing exclusively or mainly feminine subjects. In the present study too, there was evidence that the boys had a more stereotyped view of subjects than the girls, in that they rated engineering, technology and computer studies as more strongly towards the 'masculine' dimension than the girls did. However, there was no difference between males and females in their ratings of the two subjects that are perhaps most important for access to engineering, mathematics and physics, both of which were equally rated masculine by both sexes.

It is claimed that one reason that girls continue to choose sex-traditional areas of study and work, despite holding liberated views of sex roles, is because female avoidance of engineering and technology is not initiated at a conscious level (Bem, 1993; Lightbody & Durndell, 1996a, and 1998; Lightbody et al., 1997). This explanation would help to make sense of the fact that, when asked questions about their studies and career aspirations, young people tend not to construe their abilities, preferences and choices as related to gender (Lightbody and Durndell, 1996a and 1998; Francis, 2000). Rather they tend to cite personal factors, such as individual motivation (Erwin and Maurutto, 1998) to explain their 'success' in particular subjects and their choices for the future. In their studies of young people's decision-making in relation to choosing technological or 'social' careers for a hypothetical person, for example, Lightbody and Durndell found that the hypothetical person's sex was not a conscious consideration in the choice of career the respondents allocated to them. Lightbody and Durndell therefore propose that the occupational decision-making process could be more influenced by young peoples 'rational' assessments of occupations than by the fact that they hold sex-stereotypic attitudes. The suggestion is that young people's career choices may be more to do with their expectations of what a job entails than whether it is typically done by the opposite sex (Lightbody and Durndell, 1996a, 1996b and 1998). In relation to this, there is evidence, for example, that many girls seek a high level of social contact from their careers (Fuller, 1991; Lips, 1992; Lightbody et al., 1997) and believe that careers such as engineering do not offer this (Lightbody et al. 1997). This is supported by the present study, where 5% of female respondents chose 'contact with other people' as the most valued aspect of a career, compared with only 1% of the males. Furthermore, a majority of girls in this study did not perceive engineering to be a 'people' job, with more than half of the female survey respondents agreeing with the statement that 'engineering is more about working with tools and objects than working with people'. More than a third of the girls said that they were not sure and only 13% disagreed with this statement. This would indicate that one of the reasons that females are not attracted to engineering is because it is not perceived to offer them the high levels of social contact to be found in other careers. Therefore it may not be so much that a job is seen as more *appropriate* for the opposite sex than that it is not seen to offer the individual those characteristics s/he *values* in an occupation.

The weakness of this argument, however, is that it is difficult to disentangle the relationship between gender and what is valued most highly in a job. Many of the characteristics that females and males most value in an occupation tend to be found in those jobs traditionally associated with their sex, so the argument becomes somewhat circular. In this study, for example, females and males tended to prioritise different things, with the majority of girls choosing 'self-fulfilment' as the most valued aspect of a career, and the boys choosing high earnings. Certainly work values appear to be closely tied to the versions of femininity and masculinity that are constructed as appropriate for different occupations. Work values then appear to be themselves gendered and it is likely that they are both produced by, and serve to reproduce, the gendered occupational structure.

The focus group findings offered some support for the proposition that young people are able to rationally assess the gender identity implications of choosing non-traditional occupations. During the interviews, many of the girls (and indeed, quite a few of the boys) considered what it would be like to work in engineering as a woman. Certainly, the majority of girls in the interview groups constructed engineering as having a number of 'costs', including the possibility of male hostility, a potential conflict between managing the job and their future expected role as mothers, and the need to 'prove' themselves as good as the men. Although just how much these respondents actually 'know' about engineering is uncertain, these are views that have been found consistently in other studies of female engineers (Bryant, 1984b; Cockburn, 1985a; Carter and Kirkup, 1990; Henwood, 1996), where female engineers have spoken of exactly these experiences. Given young women's expectations of such costs, it would therefore be rational and pragmatic for them to choose careers that they believe will not present them with these obstacles (Cockburn, 1985a; Carter and Kirkup, 1990; Stolte-Heiskanen, 1991; Lightbody and Durndell, 1998; Glover and Fielding, 1999). It may well be then, that even if young people do not *personally* hold sex-stereotyped beliefs about careers, nonetheless the existing sexual division of labour continues to exert a structural constraint on their choices because they are able to anticipate the consequences of making a 'non-traditional' career choice for their gender identities. This will not be a uniform process for all young people, however. For some groups, like the female software engineers in Henwood's study (Henwood, 1996 and 1998), these are costs that are worth paying, while for others, the price will be too high. It will very much depend upon how they position themselves in relation to dominant models of masculinity and femininity. However, it is not simply that engineering is compatible with masculinity and incompatible with femininity. The rejection or otherwise of an occupation such as engineering will also depend upon the particular *versions* of femininity or masculinity that are constructed in relation to that occupation and to what extent a young person is able to identify with them or successfully resist them. Before considering this further in relation to choices towards engineering, it will be useful to discuss those findings that focused specifically on engineering.

Aspirations towards Engineering

The key dependent variable in this research was intention towards engineering. Of the survey respondents, fifteen per cent of the sample said they were 'likely' or 'very likely' to consider engineering as a career. This percentage is consistent with that found by MORI (2001) in the survey they undertook for the Engineering and Marine Training Authority, of young peoples' attitudes and intentions towards engineering. As expected, the boys were far more likely to say they would consider engineering than were the girls. Only 11 girls said they would consider engineering, compared with 76 boys, making boys seven times more likely than girls to consider it. Although a substantial proportion of the students said they would *consider* engineering, the percentage that actually aspired towards it was much smaller. This raises questions about how useful it was to use the term 'consider' as a measure of respondents' orientation towards engineering. On the one hand, to say one would *consider* engineering is not the same as actually making it a firm choice. On the other hand, it allowed for the respondents to express an interest, or positive orientation towards engineering without simultaneously having to commit themselves to it as a firm career intention. The advantage of this was that it provided a broader group of students whose choices towards and constructions of, academic disciplines, careers and engineering could then be compared with those not considering engineering.

Images of engineering

In the survey, images of engineering as a career were measured using 'attitude' statements about engineering with which the respondents were asked to agree or disagree. The attitude scores showed that, amongst respondents as a whole, the students' feelings towards engineering as a career might be characterised as 'indifferent'. This indifference may have been due to the students' self-declared ignorance about engineering. The respondents' lack of knowledge about engineering is supported by the view expressed in the focus groups, that engineering is somehow 'invisible' as a career, findings that are consistent with those of Harvey (1997) and Foskett and Hemsley-Brown (1997).

An unexpected finding was that there were no significant differences between the means of males' and females' attitude scores, although males were more extreme in their attitudes, with a wider range of scores than females. The group most positive towards engineering were the female 'engineers'. This may be explained by the fact that for this group, engineering would be a non-traditional choice entailing the previously discussed 'costs' for females, in turn requiring more than average enthusiasm and commitment to see it through.

In some ways, however, this may be a rather negative way of looking at it and it is important not to homogenise females and assume that the male-domination of engineering will discourage *all* girls from considering it. Indeed, it is worth noting that the sex-stereotyping of subject areas and occupations can be more of an attraction or deterrent to some pupils than others (Colley, 1998). This will depend on a number of factors, including the nature and range of the masculine or feminine identities available for an individual to take up in relation to the activity. This can be illustrated in the present study, where, in one of the focus group interviews, a male participant discussed his intentions of becoming a flight attendant, a 'caring' occupation which typically attracts more females than males. This participant was aware that the work is female-dominated and said this was a positive factor for him. He also made it clear to the group that he was a heterosexual, by saying that one of the reasons he wanted to go into the job was because he would have the opportunity to meet and have relationships with a lot of women. What was of interest here was that he felt the need to assert an actively heterosexual masculinity (as against gay masculinity?) in order to take up a legitimate identity as a flight attendant. In relation to this point, Henson and Rogers (2001) have discussed the way that men's 'location in a feminised occupation that requires the performance of emphasised femininity, including deference and caretaking behaviours, calls into question their presumed heterosexuality' (Henson and Rogers, 2001: 219). Henwood's (1998) findings on the 'non-traditional' career choices of females in a technology college also support Colley's argument that the sex-stereotyping of an occupation can be an attraction, for different reasons. In Henwood's study, the young women had chosen software engineering, not *in spite of* the fact that it is non-traditional for females, but *because* it is associated with men and therefore offered them the status 'that is associated with men, masculinity and male power' (Henwood, 1998: 39). It is possible that those girls in the present study considering engineering may also have been attracted to engineering precisely because they know it is a 'masculine' occupation that might offer them status, financial rewards and respect from their peers and others. Further research would be needed to explore this further.

The 'typical' engineer

So which students are likely to consider engineering as a career? Using correlational techniques, it was possible to build a typology of the 'typical engineer', derived from the comparisons of survey respondents grouped as 'engineers' and 'non-engineers' on a number of variables, where the differences between the two sub-groups on all the variables were statistically significant. The relevant variables fall into five broad groups, relating to: personal characteristics, subject preferences and choices, career values, awareness and knowledge of engineering and images and perceptions of engineering.

As far as personal characteristics of the 'engineers' were concerned, they were significantly more likely than the 'non-engineers' to be male and to have a male relative (usually a father) in engineering. In relation to subject preferences and choices, students considering engineering were more likely than the 'non-engineers' to be studying science and/or technology subjects at A-level. 'Engineers' were also more likely than 'non-engineers' to avoid subjects demanding substantial written components; to like practical, 'hands-on' subjects; to like exploring ideas and theories; to enjoy using computers; to like technology subjects, maths and science and to enjoy sport. In the sample as a whole, girls were significantly less likely than boys to enjoy these activities and more likely than boys to enjoy written work. In relation to career values, amongst the survey respondents as a whole, high earnings ('good money') were considered the most important factor in a job or a career. However, high earnings were much more important to those considering engineering than to those not considering it. High earnings were also more important to males than to females. Both 'engineers' and 'males' rated high earnings first, whereas for females, high earnings were in second place, after 'self-fulfilment'. Both engineers and males rated 'excitement' in third place, whilst both 'non-engineers' and females rated 'to help others' third.

The 'engineers' were more likely than the 'non-engineers' to say they knew 'quite a lot' or 'a lot' about engineering. Of those who had stated engineering as their first choice of career, 83 per cent said they knew 'quite a lot' or 'a lot' about an engineer's job, compared to only 22 per cent of those choosing occupations other than engineering. This would suggest that there is a relationship between awareness and knowledge about engineering and choosing it as a career. However it is not possible from this study to state the direction of the relationship, that is, to know whether knowledge about engineering led to choice of engineering, or the decision to pursue engineering as a career led to increased knowledge about it. Again, females were less likely than males to say they know anything about engineering.

In terms of perceptions of engineering work, the 'engineers' were more likely than the 'non-engineers' to associate engineering with particular activities such as 'designing', or 'making things' and with disciplines such as mechanical, civil, or electronic engineering. This may indicate that those considering engineering are more likely to have a broader view of what engineering involves than those not considering it. There were also some differences between the attitudes of 'engineers' and 'non-engineers' towards engineering as a career. As expected, the 'engineers' were also more likely than the 'non-engineers' to believe that engineering is an interesting career and to believe that engineering is the career of the future. 'Engineers' were more likely than the 'non-engineers' to believe that engineering requires a full-time career commitment, which could prove to be more of a barrier to those young people (mainly girls) who anticipate taking primary responsibility in the future for the care of babies and young children. Interestingly, 'engineers' were split in their response to the statement that 'engineering is difficult to get into'. 'Engineers' were more likely both to agree and to disagree with this statement than the 'non-engineers', the majority of whom were not sure. Perhaps the responses of the 'engineers' were divided because the statement that engineering is difficult to get into was rather ambiguous and could have been interpreted in either positive or negative ways, depending on the particular viewpoint taken. For example, it would be reasonable to suggest that a person considering engineering is likely to think of engineering as a high status occupation, and may be more likely therefore to agree that engineering is difficult to enter. On the other hand, respondents considering engineering may be keen to defend a view of engineering as an accessible career, and therefore more likely to disagree with the statement. 'Engineers' were also more likely than 'non-engineers' to agree that you need to be clever to become an engineer. Again this could indicate a perception of engineering as higher status amongst those who would consider it than amongst those who would not.

Two factors were noteworthy, in that they were unexpected, and could possibly be read as positive for women considering a career in engineering. The first was that the 'engineers' were more likely than the 'non-engineers' to agree that engineering is a 'people job' and the second was that 'engineers' were more likely than the 'non-engineers' to agree that women can easily combine an engineering career with having a family. These findings indicate a disparity between the way those aspiring to be engineers perceive engineering and the perceptions held by those who do not aspire to it, with the potential engineers more likely to construct engineering as a 'woman-friendly' occupation. On what evidence this assessment of engineering was based is uncertain. It was possible that some of these respondents had had first-hand experience of engineering environments, but it was also possible that it was wishful thinking, or a desire to present a gender-inclusive view on the part of some respondents.

Discussion

This study identified a number of interrelated factors that are likely to pose obstacles to both sexes' opportunities and motivations to pursue undergraduate engineering. Some of the factors related to subject choices and perceptions, and others to images and constructions of engineering as a career. These factors included: disliking the physical sciences or mathematics and opting out of these subjects after compulsory education; disliking practical 'hands on' subjects; lacking engineering 'role-models' and experience (for example, not having a relative or close friend working in the profession); being uncertain about, uninformed about or indifferent to many aspects of engineering as a career; the 'invisibility' of engineering as a career option, but particularly as an intellectual career; and having strong perceptions of engineering as a manual, dirty, boring, low status, male-dominated, female and family-unfriendly job, needing practical skills and physical strength.

What is of crucial importance in this study, concerned as it is with the low participation of women in engineering, is that on average, most of these factors are likely to pose greater obstacles to females' participation in engineering than to males. This is because those interests, activities, beliefs and behaviours associated with intentions to pursue engineering (i.e. the stereotype of the engineer) have been traditionally more typical of males' experiences than of females'. In relation to subject choices, the survey findings showed that girls in this study were both less likely than the boys to say they enjoy science, and more likely than the boys to believe that mathematics and physics are difficult subjects. It was no surprise therefore, to find that the girls in this study were less likely than the boys to have chosen to pursue these subjects for sixth form study. However, even where girls *had* chosen these subjects for sixth form study, they were much less likely than the boys to use them for an engineering career. The girls in the study were also less interested in engineering than were the boys and less likely to feel they know much about engineering. Compared with the boys, the girls were more uncertain of and unaware about many aspects of engineering as a field of study and a career. Where they held views about the nature of engineering careers, the girls were more likely to hold a narrower perception than the boys of the scope and opportunities in engineering work and tended to see it as lower status work more often than did the boys. In addition, both sexes, but particularly the girls, were aware of the potential 'costs' of entering engineering careers. These included potential male hostility, sexism and discrimination, the need to 'prove' themselves as good as the men, and the difficulties they might face in combining this kind of career with motherhood, including the ability to retain a foothold in a career driven by technological change. These costs are particularly likely to affect those girls who envisage themselves as mothers in the future, hence, to borrow the terminology of masculinity studies (for example, Connell, 1987; Mac an Ghaill, 1994), engineering is at odds with the stereotype of 'hegemonic femininity'.

Gender then, continues to be a key predictor of participation in engineering occupations. Throughout the quantitative analyses, comparisons were variously drawn between all respondents, between males and females, and between sub-groups of those students likely to consider engineering and those unlikely to consider it ('engineers' and 'non-engineers'). Given that the vast majority of those who said they were likely to consider engineering were male (87%), many of the differences found between the two sub-groups 'engineers' and 'non-engineers' were likely to be due to the gender effect (the 'non-engineers' were 62% female and 38% male). This said, when comparing the 'engineers' with wider sub-groups, it was consistently found that the 'engineers' and 'females' were the two groups that were the most polarised in their views, preferences, motivations, values and choices.

The research addressed the issue of female under-representation in engineering by examining young people's constructions of school subjects, of careers, and of engineering in order to find out whether engineering and the subjects related to it, have a masculine image. Many of the findings of this research support those of previous studies, showing that, in many ways, little has changed with respect to the educational and occupational choices of young people, which remain largely gender differentiated. Girls continue to be far less likely than boys to choose engineering careers and the association between engineering and masculinity remains strong, despite the widespread support of the view that males and females should be able to perform any job of their choosing, regardless of whether it has traditionally been associated with the other sex. However, it should be remembered that in recent years, engineering has also become a less popular career choice with boys. What the study helped to show is that in order to adequately understand the issue, it is important not to conceptualise gender merely in terms of a masculine/feminine binary. It is fair to say that engineering in the UK has historically been associated with masculinity, but what has become clearer in this work, is that engineering needs to be conceptualised in terms of its association with *specific* dominant versions of masculine identity. These are most notably: white, heterosexual, 'practical', 'sporty' men who are likely to put high earnings before fulfilment, and, to an extent, 'aspirant working class' males (Thomas, 1990: 19). This form of masculine identity is likely, therefore, to exclude ethnic minority males, gay males and many of those males who consider themselves to be 'academic', rather than practical. An awareness of gender as a *multiple* concept, and of the way that engineering and specific forms of masculinity are mutually constituted can therefore help to explain, not only why most females reject it as a career choice, but also, why it is likely to have appeal for some groups of males, but not for others. Before drawing some conclusions from these findings, the Chapter will reflect on some of the limitations and strengths of the study.

Methodological reflections

There were some limitations in the sample that have some implications for the validity of this study. One limitation was that it was not possible to achieve a true probability sample, due to the time, effort and expense this would have involved. However, by attempting to survey as large a proportion of the defined population as possible through a complete enumeration strategy, every effort was made to achieve representativeness and make the sample more statistically sound. Comparisons of sample characteristics in the present study with other studies show that generally the sample appeared to be representative of the wider population of sixth form students in co-educational comprehensive schools, therefore tentative generalisations can be made.

A second limitation of the sample was that there were not enough female 'engineers' to allow statistical comparisons of this group with other sub-groups. However, since girls aspiring to engineering are known to be a very small proportion of the population, the size of the sample would have needed to be much larger to perform such comparative analysis and this was not possible to achieve within the practical and resource constraints of the study. However, the sample was able to provide useful and up to date information about what proportion of sixth form girls would be likely to *consider* a career in engineering, data that is not readily available from other sources. The sample was also too small to allow analysis on ethnicity and analysis of social class was constrained by the limitations of obtaining data from school students, whose socio-economic status is derived from knowledge of their parents' occupational status and is likely to be unreliable, ambiguous or incomplete (Aldous, 2002: 85).

A key methodological strength of the study included the extra insights that were afforded by using both qualitative and quantitative methods. Data from the quantitative self-completion survey was able to illustrate well the larger-scale patterns of gender differences in relation to educational and occupational preferences and choices amongst a sizeable and fairly representative sample of students. Using correlational techniques of analysis also allowed those variables that were most associated with choices in engineering to be clearly identified. A substantial element of replication research allowed for comparisons to be made over time, to find out whether the patterns of gender differentiation had held.

The use of qualitative research helped to make more sense of the 'gap' between respondents' beliefs and behaviour, showing that gendered choices are not made in any simple, or pre-determined way. Although engineering is male-dominated, not all boys choose engineering and not all girls reject it. This showed it was necessary to move beyond gender as a binary term and employ a theoretical definition of gender which understands it as a multiple concept. The group interviews were also able to show, in a way that the questionnaires could not, that competing and contradictory beliefs and narratives about gender are circulating amongst young people. They showed that the students' gendered choices do not sit easily alongside their beliefs that the sexes ought to be and indeed, *are* equal, in today's society. Overall, the findings showed that masculine and feminine identities *are* attached to subject disciplines and occupations, but that understanding exactly *how* sex-stereotyping is perpetuated and how it operates to shape the educational and occupational choices of young people is no easy matter. What needed further explanation was: if most young people do not subscribe to sex-stereotypes, and hold liberal views about sexual equality, why do they continue to make sex-traditional subject and career choices?

Explaining the 'gap' between beliefs and behaviour

The inconsistency in the findings, between the students' 'equality' beliefs and their own gendered choices needed exploring further. It was worth considering that the discrepancy between participants' beliefs and behaviour could be partly due to methodological effects.

Chapter Three suggested that the interview participants may have presented an equal opportunities view in the desire to be 'politically correct' in the face of a female researcher (myself) who was clearly interested in gender issues (see also Francis, 2000: 41). In support of this argument, Kitzinger (1994: 110) has discussed how value systems and group norms inform participants' responses, at times censoring 'any deviation from group standards - inhibiting people from talking about certain things'. Smithson (2000) supports this, but takes the claim further:

> Normative influences are not limited to focus groups. Surveys, questionnaires and individual interviews can result in respondents giving accounts perceived as acceptable to the researcher. The problem may be exacerbated in focus group research by fear of peer group disapproval (Smithson, 2000: 113).

A desire to support equal opportunities may well have constituted such a value system. Indeed, Bigler (1999: 130) argues, 'the endorsement of rigid beliefs about the appropriate roles and traits for men and women is now widely regarded as undesirable'. Once the participants had become aware that the research was concerned with gender, it would be a short step for many of them to guess that it could also be feminist in orientation and indeed, one or two interview participants made it clear they were aware of this in post-interview debriefing sessions. As touched upon in Chapter 3, this awareness may well have caused some participants to respond in a way they considered to be appropriate, or 'pleasing' to a female (and feminist) researcher, particularly in the face-to-face setting of the interviews (Francis, 2000). This effect has been described by Oppenheim (1992) and Robson, (1993) as 'social desirability bias'. Interestingly, however, and possibly in support of Smithson's above cited claim, the equal opportunities beliefs were not only evident in the interviews, but also reflected in the responses of the questionnaire respondents in this study. When asked to assign a list of subjects as best suited to males or females, the vast majority of respondents rated all subjects *except engineering* as equally suited to males or females. This finding supports those found in Whitehead's (1996) questionnaire survey of Year 13 students, where in response to an item measuring perceptions of gender and ability, the majority of respondents believed that both sexes were equally good at all academic subjects. There were, however, some slight differences between Whitehead's study and the present one. Firstly, engineering was not a subject included in Whitehead's study and secondly, more strongly stereotyped views were found in her study in relation to modern languages, which a majority of respondents thought girls are better at, and also in relation to physics and chemistry, which a majority of respondents thought boys are better at. For the questionnaire respondents in the present study, it was possible that one reason for choosing the egalitarian response may have been response fatigue. Having noted that the self-completion questionnaire was fairly lengthy, one of the less onerous and quickest ways to complete the question about the gender-appropriateness of a list of subjects would have been to tick the option giving a gender-neutral response (equally suited to males and females) for every subject, rather than spending time thinking about a separate response for each one.

Social desirability bias and response fatigue may well have played a part in producing the inconsistency between participants' beliefs and choices. However, given the consistency of findings like these across a number of other studies using different methods (see Whitehead, 1996; Francis, 2000), it is unlikely to provide more than a partial explanation. There was therefore a need to think further about why there was such a discrepancy between respondents' beliefs about gender and the choices they had made for themselves. At best, the idea that girls are discouraged from studying and working in the physical sciences, technology and engineering because they think them inappropriate for females can only be part of the story. As has been shown, the survey findings suggest that the majority of students in this study would not consider themselves to hold sex-stereotyped beliefs. Despite this however, discourses that reinforce traditional sex-stereotypes were found in the analyses of the focus groups. It became evident in the focus groups that despite the general commitment to sexual equality, the idea of girls and boys crossing the traditional boundaries of their sex had implications for the students' identities and in particular, for their sexual identities. Examples of this will be discussed further in the concluding section of the Chapter, which attempts to make sense of this and other findings.

Conclusion

Perhaps one of the best means for capturing the complexity of the ways in which gendered behaviour is reproduced, is provided by those theories that emphasise the power of 'gender discourses' to structure and limit opportunities for young people (Henwood, 1999; Francis, 2000). The idea that there are multiple and competing discourses about gender helps to explain why young people both appear to hold contradictory views about certain issues, and make choices that appear to contradict their beliefs. Two discourses appeared to be dominant in the focus group interviews. The first of these might be termed the discourse of 'compulsory heterosexuality' (Rich, 1980; Mac an Ghaill, 1994: 9; Epstein and Johnson, 1998: 6), whereby 'homophobic and heterosexist' discourses are dominant and dictate that heterosexuality is compulsory (Epstein and Johnson, 1998: 6). This discourse acts to police sex/gender boundaries, masculinities and femininities through ridicule and homophobic insults. In the context of this research, although the participants did not appear to consciously hold stereotyped views, the associations between sexuality, subject disciplines and careers in particular were strong enough for any student making a non-traditional, or 'cross-gender' subject or career choice to risk having their sexuality called into question by the peer group. Measor (1983) gives an example of how this discourse works in an early study of school pupils. One boy, because he did not like science and admitted that he was afraid of the bunsen burners, was 'taunted about his sexuality, criticized for not being masculine enough' and earned the title of 'poofter' (Measor, 1983: 181). Examples of this were also found in the present study. Firstly, there were inferences that men working in the beauty industry are homosexual, and that female builders are lesbians. Secondly, a male student aspiring to become a flight attendant needed to assert his heterosexual identity in opposition to a gay masculinity in order to take up a legitimate identity in this occupation. Thirdly, the idea of women working as engineers was ridiculed in one male group, with the suggestion, accompanied by much hilarity, that they would be dropping 'pink' business cards around.

A second dominant discourse, is what both Henwood (1996) and Francis (2000: 41) have referred to as 'the liberal discourse of Equal Opportunity'. This discourse says that 'opportunities exist', so if girls follow sex-traditional educational and occupational paths, 'it follows that they must have chosen freely to be there' (Henwood, 1996: 212). These ideological mechanisms of gender-inequality are more powerful precisely because they are not easily apparent to the individual, who, in subscribing to the liberal discourse, feels in charge of her destiny and in so doing, accepts responsibility for her 'choices', which she presents as gender-neutral. But, this freedom is an illusion, as Walkerdine (1989) in her study of girls and mathematics, argued

> 'the fantasy of the rational and autonomous subject' is 'a fiction of a freedom produced in a political order which disguises the oppression required to produce the subject who imagines 'himself' free to act as 'he' chooses' (Walkerdine, 1989: 209).

Importantly, the discourse of individualism is harmful because it contradicts the ability to understand gendered inequality (Erwin and Maurutto, 1998) as accepting the liberal discourse of equal opportunities has the effect of masking inequalities between the sexes (Francis, 2000). In this discourse, since girls and women are believed to have equal access to education and jobs, it is also assumed that there are no barriers to females, *other than those girls and women put in their own way*, through their choices, preferences and 'avoidance' of disciplines like engineering. In other words, along with the assumption of gender equality, educational and occupational choices become individualised, therefore any residual female 'inequality', such as female under-representation in engineering, is perhaps more likely than ever, to be perceived to be the 'fault' of the individual girls and women. Henwood (1998) illustrates just how powerful this discourse is, when even those women who *do* become engineers find it hard to challenge the dominant discourse on gender-technology relations. As Henwood (1998) observes, they often try to do this in 'very individualistic ways by distancing themselves from "other women" or "women in general", presenting themselves as "exceptions", a construction that leaves the gendered dualisms untouched' (Henwood, 1999: 24). If young women *do* think engineering is an occupation more appropriate for men, they are not wrong, engineering in its present form *is* more appropriate for men in the sense that it is an occupation that continues to compromise and exclude the desires and needs of many women. However, as we have seen, the construction of engineering as synonymous with a *specific* masculine identity also acts to exclude many men.

So what are the implications of these arguments for female under-representation in engineering? Outside feminism, it is fair to say that amongst most initiatives tackling the low participation of women in engineering, science and technology, the primary emphasis is firmly upon 'choice', agency and the belief that women have excluded themselves, rather than being denied access. Meanwhile, the roles played by structural, cultural and environmental factors, such as gendered classroom practices, the masculine culture of engineering and the gendered occupational structure, fade into the background. This thesis has discussed how, despite a wealth of feminist critiques of the limitations of equal opportunities approaches and the liberal individualist philosophy underpinning them (Arnot 2002), many 'mainstream' approaches to the issue of female under-representation in engineering continue to be individualistic and voluntaristic, blaming the sex-stereotyped attitudes and choices of individual girls and women. The government, equality bodies and the Engineering Profession all continue to perpetuate the view that young women are 'missing out' and failing to take up opportunities in engineering work because of their misguided sex-stereotyped beliefs about the discipline. Commenting on the Equal

Opportunities Commission's *What's stopping you?* campaign, Estelle Morris, then Secretary of State for Education said:

> the EOCs campaign to challenge sex stereotyping and widen choices promises to play an important part in increasing young people's awareness of the possibilities open to them. It will help them recognise that their horizons need not be limited by narrow expectations or fixed stereotypical ideas. I am very pleased that the EOC has launched this campaign and I wish it every success (EOC, 2001).

The contradictions within this study have shown that it is a mistake to conceptualise young people's choices in these overly voluntaristic terms. Rather, gendered educational and occupational choices can be seen to result from more complex and 'hidden' ideological mechanisms by which gender shapes and constrains behaviour, beliefs and choices. An alternative understanding of sex-stereotypes as produced and reproduced within discourse, helps to understand sex-stereotyping, not as properties of individuals (i.e. fixed attributes) but as a *social process*, as part of the wider social and cultural environment in which choices are made. Within the terms of the CMO model, sex-stereotypes may be better visualised as part of the context (C), rather than the mechanism (M), by which the under-representation of women in engineering (O) is reproduced. The mechanism is perhaps better conceptualised as the dominant gender discourses which young people themselves are active in making and remaking and which serve to shape meanings and understandings, silencing others and closing off opportunities for both sexes. Understanding the ways in which these ideological mechanisms block women's access to engineering in this way, as opposed to blaming girls and women for their faulty attitudes, may help us come closer to opening up opportunities for women (and men) in engineering.

In some ways, occupational gender segregation is even more difficult to explain and tackle now than it may have been in the past. This is because the dominant discourses, i.e. of individuality, of equal opportunity, are able to perform the trick of obscuring gendered power relations (Walker, 2001), in a discourse of gender neutrality. While young people's subject and career choices continue to be seen by themselves and others within the discourse of individuality, initiatives to address sex stereotyping in occupations will continue erroneously to encourage young people to choose non-traditional options, with limited success.

In setting out to assess the proposition that engineering is considered masculine, the research inevitably concerned itself with the wider issue of occupational sex-stereotyping. It found evidence that sex-stereotypes do continue to shape and limit young people's opportunities, not only in engineering, but also in a much wider range of occupations. Perhaps amongst the most important findings of this research were a deeper insight into the *process* by which sex-stereotypes are perpetuated and a deeper understanding of gender as multiple, not dichotomous, and the implications this could have for opening up a wider range of educational and occupational identities. Future projects need to concern themselves with how best to achieve this goal.

APPENDIX I

GROUP INTERVIEW GUIDE (for 45-60 minute interviews)

Name of school/college ....

Date .... No of participants: Girls ☐ Boys ☐

(Notes to self: *Introduction, thanks for participating, draw, purpose of study, planned content of interview and possible uses of the data. Taping to aid continuity, but identities will remain anonymous. Rights to withdraw, refuse any questions, confidentiality ensured. Happy to answer any questions participants might have at the end. Assure the group that I want to hear all their views, and that there are no right and wrong answers*).

1. A level Choices

1. Could I ask you each in turn to say your first name and which subjects you are studying?

2. How did you choose which subjects to study at A level?

3. Do you think that some subjects are more difficult than others?

4. Were there subjects you'd have liked to study that were not available?

5. Do you think that girls/boys are better at some subjects than boys/girls?

2. Employment

1. Do you have any current career ambitions?

2. What would you seek most from a job?

3. Are there any jobs you wouldn't want to do?

4. How would you feel about working in a job in which you were the only male/female?

5. Do you think men/women are better suited to some types of work?

APPENDIX I (CONTINUED)

3. Engineering

1. Are any of you considering engineering as a career?

2. Do any of you have relatives or friends who are engineers?

3. If someone says they're an engineer, what do you imagine them doing?

4. Which types of engineering do you think are the most interesting?

5. Would you say some types of engineering are more useful to society than others?

6. How does a person become an engineer?

Do you think engineering is something you'd consider doing? Why would you not choose engineering as a career?

7. Do you think that there are particular types of engineering work that women would be good at?

8. Would women going into engineering face any particular challenges or difficulties?

APPENDIX II

COMPOSITION OF INTERVIEW GROUPS

Group 1
Bristol school. Eight male participants, studying the following subject combinations:

1. A levels - Business Studies, Geography and English
2. A levels - Maths, Physics and Chemistry
3. A levels - Maths, Physics and Computing
4. A levels - Chemistry, Business Studies and History
5. A levels - Mathematics, Chemistry and Biology
6. A levels - History, English and Drama
7. GNVQ - Leisure and Tourism (intermediate level)
8. GNVQ - Leisure and Tourism (intermediate level)

Group 2
School as Group One. Seven female participants, studying the following subject combinations:

1. A levels - History, Drama and English Literature
2. A levels - History, Chemistry and Business Studies
3. A levels - History, Biology and English Literature
4. GNVQ - Business (intermediate level)
5. GNVQ - Business (intermediate level)
6. GNVQ - Business (intermediate level)
7. GNVQ - Business (intermediate level)

Group 3
Plymouth school. Six male participants, studying the following subject combinations:

1. A levels - Maths, Sociology and History
2. A levels - Maths, Chemistry and Biology
3. A levels - Maths, Chemistry and Physics
4. A levels - Maths, Physics and Biology, AS - Further Maths
5. A levels - Maths, Business & Economics and Geography
6. A levels - Maths, Physics and Art

Group 4
School as Group Three. Eight female participants, studying the following subject combinations:

1. A levels - English Literature, History and French
2. A levels - English Literature, History and French
3. A levels - English Literature, History and Maths
4. A levels - English Literature, History and French
5. A levels - English Language and Art (taking AS levels in Biology and Maths in Year 13)
6. A levels - English Language, Sports Studies and Geography
7. A levels - Chemistry, Biology and Maths
8. A levels - Chemistry, Biology and English Language

APPENDIX II (CONTINUED)

Group 5
Plymouth school. Seven males, studying the following subject combinations:

1. A levels - Economics, Business Studies, Art and General Studies
2. A levels - Maths, Chemistry and Biology
3. A levels - Maths, Economics, Business Studies and General Studies
4. A levels - Biology, History and General Studies
5. A levels - Sociology, English and Theatre Studies
6. A levels - Sociology, History, Religious Studies and General Studies
7. GNVQ - Engineering

Group 6
School as Group Five. Five females, studying the following subject combinations:

1. A levels - English, Business Studies, Religious Education and General Studies
2. A levels - Biology, Sociology and Theatre Studies
3. A levels - Biology, French and General Studies
4. A levels - Maths, Spanish and Theatre Studies, AS - Music
5. GNVQ - Business (advanced level)

Group 7
Bristol School. Six males, studying the following subject combinations:

1. A levels – Maths, Physics and Geography
2. A levels – Maths, Physics and Art
3. A levels – Maths and Physics
4. A levels – Biology and Geography
5. A levels – Maths, Physics and Chemistry
6. A levels – Maths, Physics and Chemistry, AS - Further Maths

Group 8
School as Group Seven. Nine females, studying the following subject combinations:

1. A levels – Maths, Chemistry and Biology
2. A levels – Biology, English Literature and Art
3. A levels – Biology, English Literature and Chemistry
4. A levels – History, Sports Studies and Sociology
5. A levels – Biology and Sociology
6. A levels – Art and Sociology
7. A levels – History, English Literature and Sociology
8. A levels – History, Music and Sociology
9. A levels – Biology and Art (taking AS in Computer Studies in Year 13)

APPENDIX III

SUBJECTS STUDIED BY FOCUS GROUP INTERVIEW PARTICIPANTS

A LEVEL SUBJECTS	MALES	FEMALES	TOTAL STUDYING SUBJECT
ART	3	4	7
BIOLOGY	**6**	**10**	**16**
BUSINESS STUDIES*	5	2	7
CHEMISTRY	8	5	13
COMPUTER STUDIES	1	0	1
DRAMA	1	1	2
ECONOMICS	2	0	2
ENGLISH (Literature & Language)	**3**	**13**	**16**
FRENCH	**0**	**4**	**4**
GENERAL STUDIES	4	2	6
GEOGRAPHY	4	1	5
HISTORY	**5**	**10**	**15**
MATHS	**16**	**4**	**20**
MUSIC	0	1	1
PHYSICS	**10**	**0**	**10**
RELIGIOUS STUDIES	1	1	2
SPANISH	0	1	1
SOCIOLOGY	3	6	9
SPORTS STUDIES	0	2	2
THEATRE STUDIES	1	2	3
AS LEVEL SUBJECTS STUDIED	**MALES**	**FEMALES**	
FURTHER MATHS	2		
MUSIC		1	
GNVQ SUBJECTS STUDIED	**MALES**	**FEMALES**	
BUSINESS		5	
ENGINEERING	1		
LEISURE & TOURISM	2		
TOTAL PARTICIPANTS	**MALES**	**FEMALES**	**N**
	27	29	56

APPENDIX IV

QUESTIONNAIRE

B

YEAR 12 QUESTIONNAIRE

The University of Plymouth is conducting a survey to find out about Year 12 students' choices in education and employment and their perceptions of engineering as a career. This research should help universities to produce information which will allow young people to make more informed choices about courses and careers.

We would be very grateful if you could help us by giving us your views. Please complete this questionnaire as fully as possible (this should take about 15 minutes). We do not need your name and all the information you give us will be treated as completely confidential.

All those who complete a questionnaire have a chance of winning one of three £10 Virgin Records gift tokens. To ensure you have a chance of winning, ***please tear off and keep safely the number at the <u>bottom right hand corner</u> of this page*** (the duplicate number at the top will be entered into a raffle). The winning numbers will be drawn when we have received all completed questionnaires from the participating schools. The winners will receive their prizes via their schools.

Thank you for taking part

RAFFLE No:

We'd like to start by asking you some questions about yourself:

1. What was your age last birthday?: ☐☐ years

2. Are you male? ☐ or female? ☐

3. How well do the following statements describe you? *(please tick <u>one</u> box for each statement)*

	Yes I am like this	No I am not like this	I'm Not sure
I enjoy being creative	☐	☐	☐
I enjoy technology subjects	☐	☐	☐
I enjoy theories and abstract thinking	☐	☐	☐
I enjoy practical tasks	☐	☐	☐
I enjoy maths	☐	☐	☐
I enjoy finding out about people	☐	☐	☐
I enjoy using computers	☐	☐	☐
I am interested in environmental issues	☐	☐	☐
I enjoy learning another language	☐	☐	☐
I enjoy problem-solving tasks in maths, science or technology	☐	☐	☐
I am career-minded	☐	☐	☐
I enjoy tasks which require me to be imaginative	☐	☐	☐
I enjoy science	☐	☐	☐
I like taking part in group discussions and debates	☐	☐	☐
I enjoy doing sport	☐	☐	☐
I enjoy writing	☐	☐	☐

We'd now like to ask some questions about your studies

4. Which subjects are you studying in **Year 12**? (*please list* <u>*all*</u> *subjects studied in the appropriate category/categories below*):

GNVQs	A levels
....	....
....	....
....	....
....	....
....	....

AS levels	Other (*please specify subject and type, e.g. GCSE*)
....	....
....	....
....	....
....	....
....	....

5. How influential were the following on your choice of subjects at **Year 12**? (*please tick the relevant box for each*)

	Very influential	Influential	Slightly influential	Not at all influential
Parents/Step-parents/Guardians	☐	☐	☐	☐
Brothers/Sisters	☐	☐	☐	☐
Other relation	☐	☐	☐	☐
Friend	☐	☐	☐	☐
Careers adviser/teacher	☐	☐	☐	☐
Other teacher	☐	☐	☐	☐
Media (e.g. TV, CDRom, internet)	☐	☐	☐	☐
School talks or visits	☐	☐	☐	☐
Libraries	☐	☐	☐	☐
Other (*please write in*)	☐	☐	☐	☐

....

6. How much do you agree or disagree with each of the following reasons for your choice of subjects at **Year 12**? (*please tick* <u>*one*</u> *box for each statement*)

	Strongly Agree	Agree	Disagree	Strongl disagre
I thought I would have a chance of passing these subjects	☐	☐	☐	☐
I thought these subjects would be interesting	☐	☐	☐	☐
I like fact-based subjects	☐	☐	☐	☐
I need these subjects for my intended career	☐	☐	☐	☐
I wanted to avoid subjects which require a lot of written work	☐	☐	☐	☐
I wanted to do subjects which have a high status with universities and employers	☐	☐	☐	☐
I like subjects where you learn about people	☐	☐	☐	☐
I enjoy subjects where you can explore ideas and theories	☐	☐	☐	☐
I thought other subjects would be too difficult	☐	☐	☐	☐
I enjoy subjects which involve practical, 'hands on' activities	☐	☐	☐	☐
I did well in these subjects at GCSE	☐	☐	☐	☐

7. Were there any subjects you would have liked to study in **Year 12**, but couldn't, for some reason?

Yes ☐ No ☐ (*if NO, please go to question 10*) ↓

8. Which subjects were they? (*please write in below*)

Subject 1: ....

Subject 2: ....

Subject 3: ....

9. Which (if any) of the following reasons prevented you from studying the subject(s) you wanted in **Year 12**? (*please tick reason for each subject*):

	Subject 1	Subject 2	Subject 3
this subject clashed on the timetable with another subject I wanted to study	☐	☐	☐
this subject not offered at my school	☐	☐	☐
not enough people chose this subject to run the course	☐	☐	☐
I found this subject too difficult in Year 12, so dropped it	☐	☐	☐
not enough time to study this subject in addition to my other ones	☐	☐	☐
other reason	☐	☐	☐

10. Which (if any) of the following design/technology options did you study in **Years 10 and 11**? (*please tick*)

Food ☐ ☐ Graphic products

Textiles ☐ ☐ Materials

Electronic products ☐ ☐ Product Design

Other (*please write in*) ☐

....

11. Do you see each of the following subjects as **'scientific'** or **'arty'**?
(please tick one box for each subject)

	Very scientific	Quite scientific	Both scientifc and arty	Quite arty	Very arty
French	☐	☐	☐	☐	☐
Mathematics	☐	☐	☐	☐	☐
Biology	☐	☐	☐	☐	☐
Drama	☐	☐	☐	☐	☐
Physics	☐	☐	☐	☐	☐
Sports Studies	☐	☐	☐	☐	☐
Chemistry	☐	☐	☐	☐	☐
English	☐	☐	☐	☐	☐
Technology	☐	☐	☐	☐	☐
Business Studies	☐	☐	☐	☐	☐
History	☐	☐	☐	☐	☐
Art	☐	☐	☐	☐	☐
Engineering	☐	☐	☐	☐	☐
Sociology	☐	☐	☐	☐	☐
Computer Studies	☐	☐	☐	☐	☐
Psychology	☐	☐	☐	☐	☐

12. Please rate the following subjects as to whether you think they **are best suited to males** or **best suited to females** (*please tick* *<u>one</u>* *box for each subject*)

	Definitely best suited to males	On the whole best suited to males	Equally suited to males or females	On the whole best suited to females	Definitely best suited to females
French	☐	☐	☐	☐	☐
Mathematics	☐	☐	☐	☐	☐
Biology	☐	☐	☐	☐	☐
Drama	☐	☐	☐	☐	☐
Physics	☐	☐	☐	☐	☐
Sports Studies	☐	☐	☐	☐	☐
Chemistry	☐	☐	☐	☐	☐
English	☐	☐	☐	☐	☐
Technology	☐	☐	☐	☐	☐
Business Studies	☐	☐	☐	☐	☐
History	☐	☐	☐	☐	☐
Art	☐	☐	☐	☐	☐
Engineering	☐	☐	☐	☐	☐
Sociology	☐	☐	☐	☐	☐
Computer Studies	☐	☐	☐	☐	☐
Psychology	☐	☐	☐	☐	☐

13. Please rate the following subjects as to whether they are to do with **people** or **things** *(please tick one box for each subject)*

	Mainly about people	Quite a lot to do with people	Both about people *and* things	Quite a lot to do with things	Mainly about things
French	☐	☐	☐	☐	☐
Mathematics	☐	☐	☐	☐	☐
Biology	☐	☐	☐	☐	☐
Drama	☐	☐	☐	☐	☐
Physics	☐	☐	☐	☐	☐
Sports Studies	☐	☐	☐	☐	☐
Chemistry	☐	☐	☐	☐	☐
English	☐	☐	☐	☐	☐
Technology	☐	☐	☐	☐	☐
Business Studies	☐	☐	☐	☐	☐
History	☐	☐	☐	☐	☐
Art	☐	☐	☐	☐	☐
Engineering	☐	☐	☐	☐	☐
Sociology	☐	☐	☐	☐	☐
Computer Studies	☐	☐	☐	☐	☐
Psychology	☐	☐	☐	☐	☐

14. Thinking back to GCSEs, how **difficult** or **easy** did you find the following subjects? (*please tick one box for each subject*):

	Very difficult	Quite difficult	Neither difficult nor easy	Quite easy	Very easy	Did not study thi: subject
French	☐	☐	☐	☐	☐	☐
Mathematics	☐	☐	☐	☐	☐	☐
Biology	☐	☐	☐	☐	☐	☐
Drama	☐	☐	☐	☐	☐	☐
Physics	☐	☐	☐	☐	☐	☐
Sports Studies	☐	☐	☐	☐	☐	☐
Chemistry	☐	☐	☐	☐	☐	☐
English	☐	☐	☐	☐	☐	☐
Technology	☐	☐	☐	☐	☐	☐
Business Studies	☐	☐	☐	☐	☐	☐
History	☐	☐	☐	☐	☐	☐
Art	☐	☐	☐	☐	☐	☐
Engineering	☐	☐	☐	☐	☐	☐
Sociology	☐	☐	☐	☐	☐	☐
Computer Studies	☐	☐	☐	☐	☐	☐
Psychology	☐	☐	☐	☐	☐	☐

We'd now like to ask you some questions about your future plans:

15. Do you have any general career plans at the moment?

Yes ☐ No ☐ *(if NO, please go to question 17)* ↓

16. Which job(s) or career(s) are you considering? (*please write in space below*)

First choice: ....

Second choice: ....

17. How much would you say you know about what people in the following jobs do in their work? (*please tick <u>one</u> box for each job*):

	nothing at all	not much	a little	quite a lot	a lot
Accountant	☐	☐	☐	☐	☐
Teacher	☐	☐	☐	☐	☐
Vet	☐	☐	☐	☐	☐
Engineer	☐	☐	☐	☐	☐
Solicitor	☐	☐	☐	☐	☐
Police officer	☐	☐	☐	☐	☐
Secretary	☐	☐	☐	☐	☐
Firefighter	☐	☐	☐	☐	☐
Nurse	☐	☐	☐	☐	☐
Journalist	☐	☐	☐	☐	☐
Graphic Designer	☐	☐	☐	☐	☐

18. Which **five** of the items below would be most important to you in a job or career? (*please tick five items in* ***column A****, then rank your chosen five in*
column B *in order of importance, where 1 = most important and 5 = fifth in importance*)

	A Please tick 5	B Rank no:
chances for advancement	☐	....
variety	☐	....
good money	☐	....
job security	☐	....
contact with other people	☐	....
self-fulfilment	☐	....
to become famous	☐	....
ability to combine career and family	☐	....
to make things	☐	....
outdoor environment	☐	....
status and respect from others	☐	....
to make my own decisions	☐	....
chance to help others	☐	....
the challenge of difficult work	☐	....
excitement	☐	....
other (*please write in*)	☐	....

....

We'd now like to ask you some questions about engineering:

19. How much would you say you know about engineering? (*please tick <u>one</u> box*)

Nothing at all	Not much	A little	Quite a lot	A lot
☐	☐	☐	☐	☐

20. What are the first words you think of when you hear the word 'engineer'? *(please write in space below)*

....

21. How likely or unlikely are you to consider a career in engineering? (*please tick one box*)

Very unlikely	Fairly unlikely	Fairly likely	Very likely	Don't know
☐	☐	☐	☐	☐

22. a) Are any members of your family, or circle of close friends engineers?

Yes ☐ No ☐ (*if NO, please go to question 23*) ↓

b) What is their relationship to you? (*please write in below, e.g. mother, father, sister, friend's father, uncle*)

....

c) Please briefly describe the kind of work they do

....

23. Which **five** of the following attributes do you think are most needed by engineers? (*please tick five items in **column A**, then rank your chosen five in*
***column B** in order of importance, where 1 = most important and 5 = fifth in importance*)

	A Please tick 5	B Rank No:
good imagination	☐	....
career-minded	☐	....
respects the environment	☐	....
physical strength	☐	....
scientific knowledge	☐	....
verbal communication skills	☐	....
creativity	☐	....
enjoys working with other people	☐	....
written skills	☐	....
interested in people	☐	....
mathematical knowledge	☐	....
practical skills	☐	....
able to manage people and projects	☐	....

24. How much do you agree or disagree with the following statements? (*please tick* <u>*one*</u> *box for each statement*)

	Strongly agree	Agree	Not sure	Disagree	Strongly disagree
Engineering is one of the most difficult careers to get in to	☐	☐	☐	☐	☐
Engineering is a really interesting career	☐	☐	☐	☐	☐
These days, more and more women are becoming engineers	☐	☐	☐	☐	☐
Engineering is a career which requires a full-time career commitment	☐	☐	☐	☐	☐
People who become engineers are generally not very interested in people	☐	☐	☐	☐	☐
Engineering is a man's world	☐	☐	☐	☐	☐
Training to become a professional engineer is no more difficult than training to become a lawyer or a teacher	☐	☐	☐	☐	☐
Engineering seems boring compared to other jobs	☐	☐	☐	☐	☐
A woman going into engineering would have to cope with hostile remarks from the men	☐	☐	☐	☐	☐
You need to be clever to become an engineer	☐	☐	☐	☐	☐
Men are far more likely to take up careers in engineering than women are	☐	☐	☐	☐	☐
In today's technological world, engineering is the career of the future	☐	☐	☐	☐	☐
In engineering you can't afford to take a career break	☐	☐	☐	☐	☐

	Strongly agree	Agree	Not sure	Disagree	Strongly disagree
Engineering is more about working with tools and objects than working with people	☐	☐	☐	☐	☐
The prospect of working in a nearly all-male environment is off-putting	☐	☐	☐	☐	☐
At university, science and technical courses leave you with less leisure time than other courses	☐	☐	☐	☐	☐
Women engineers can easily combine their career with having a family	☐	☐	☐	☐	☐

We'd now like to ask you some questions about your parents/guardians' jobs and education. By parents/guardians we mean the adults with whom you live most of the time and who are responsible for you. This includes step parents, foster parents etc.:

25. a) If your mother/guardian is working, please tell us the title of her job

....

b) Did she: (*please tick all that apply*)

leave school at 15/16? ☐
leave school after A levels? ☐
go to college after A levels? ☐
go to polytechnic/university? ☐
not sure ☐

26. a) If your father/guardian is working, please tell us the title of his job

....

b) Did he: (*please tick all that apply*)

- leave school at 15/16? ☐
- leave school after A levels? ☐
- go to college after A levels? ☐
- go to polytechnic/university? ☐
- not sure ☐

Finally, we'd like to ask you about your ethnic identity

27. Which of the following best describes you?
(*please tick one box only*)

- Black British ☐
- Black Caribbean ☐
- Black African ☐
- Cornish ☐
- English ☐
- Irish ☐
- Scottish ☐
- Welsh ☐
- Greek ☐
- Indian ☐
- Pakistani ☐
- Bangladeshi ☐
- Chinese ☐
- Other (*please write in*) ....

THANK YOU VERY MUCH
DON'T FORGET TO TEAR OFF AND KEEP YOUR RAFFLE NUMBER ON THE FRONT OF THIS QUESTIONNAIRE!

APPENDIX V

ALLOCATION OF SURVEY RESPONDENTS' CAREER CHOICES TO OCCUPATIONAL CATEGORIES

1. Animal-related work animal physiotherapy dog handling farrier laboratory work in vet practice vet veterinary nurse veterinary science zoo work	**6. Catering** chef 'catering'
2. Architecture/construction architect	**7. Child-related work** children's nurse child psychologist children's tour rep nursery nurse nanny
3. Art & Design/Graphics fashion design furniture design interior design internet/web design photography product design window dressing	**8. Clerical and administrative** administrative work clerical, secretarial office work PA telephonist/receptionist
4. Armed Forces army, airforce marines military police navy RAF	**9. Computer-related** computer analyst computer programmer computer science computer technician Information Technology
5. Business accountancy actuarist advertising banking buyer marketing management own business personnel management retail stock exchange	**10. Craft/trades** builder electrician landscape gardener mechanic painter/decorator

APPENDIX V (CONTINUED)

11. Engineering computer engineer design engineer software engineer	**16. Medicine, Allied to Medicine & dentistry** GP occupational Therapist pharmacist podiatry speech Therapist surgeon physiotherapy
12. Emergency Services firefighter police officer paramedic	**17. Nursing** nurse midwife NB: not children's nurse, which is in category 7 (child-related)
13. Languages Interpreter Translator	**18. Entertainment/Performing arts** actor animator choreographer costume/theatre designer dancer drama model musician presenter - TV producer – film/TV/radio scriptwriter singer, songwriting skateboarder writer (e.g. novels)
14. Law barrister lawyer solicitor	**19. Personal services** aromatherapist beautician beauty therapist body artist flight attendant hairdresser reflexologist shop assistant/checkout supervisor
15. Media advertising Journalism publishing sales	**20. Psychology/Counselling** NB: not child psychologist, which is in category 7 (child-related). criminal psychologist counsellor psychotherapist

APPENDIX V (CONTINUED)

21. Social work/Care care assistant disabled care health and social care social worker support worker	**24. Teaching** NB: not PE teacher, which is in category 22 (sport-related)
22. Sport-related fitness instructor gym instructor lifeguard outward bound instructor PE teacher sports journalist	**25. Tourism** customs officer hotel and catering Red-coat tour rep
23. Science-based biologist biochemist ecologist environmental chemist food scientist forensic science/pathology genetic scientist geologist marine biology nutritionist palaeobiologist physics	**26. Other/unable to classify** agriculture aircraft technician astrology bio-mechanics coroner factory work fashion geography higher education course historian international relations librarian people-related pilot politician psychic healer spy technician (unspecified area)

APPENDIX VI

CATEGORIES OF THE SOCIO-ECONOMIC CLASSIFICATION (SEC)

THE FULL VERSION

L1 **Employers in large organizations**

L2 **Managers in large organizations**

L3 **Professionals**
- L3.1 'Traditional
- L3.2 'New'

L4 **Associate professionals**
- L4.1 'Traditional'
- L4.2 'New'

L5 **Managers in small organizations**

L6 **Higher supervisors**

L7 **Intermediate occupations**
- L7.1 Intermediate clerical and administrative occupations
- L7.2 Intermediate service occupations
- L7.3 Intermediate technical occupations

L8 **Employers in small organizations**
- L8.1 Employers in small organizations in industry, commerce, services etc.
- L8.2 Employers in small organizations in agriculture

L9 **Own account workers**
- L9.1 Own account workers (non-professional)
- L9.2 Own account workers in agriculture

L10 **Lower supervisors**

L11 **Craft and related occupations**

L12 **Semi-routine occupations**
- L12.1 Semi-routine sales occupations
- L12.2 Semi-routine service occupations
- L12.3 Semi-routine technical occupations
- L12.4 Semi-routine operatives
- L12.5 Semi-routine agricultural workers

L13 **Routine occupations**
- L13.1 Routine service occupations
- L13.2 Routine production occupations
- L13.3 Routine operatives

APPENDIX VI (CONTINUED)

L14 Never worked and long-term unemployed
- L14.1 Never worked
- L14.2 Long-term unemployed

L15 Full-time students

L16 Occupations not stated or inadequately described

L17 Not classifiable for other reasons

THE THREE CLASS VERSION

Class I: Managerial & Professional

- L1 Employers (large)
- L2 Managers (large)
- L3.1 Professionals (traditional)
- L3.2 Professionals (new)
- L4.1 Associate professionals (traditional)
- L4.2 Associate professionals (new)
- L5 Managers (small)
- L6 Higher supervisors

Class II: Intermediate

- L7.1 Intermediate clerical
- L7.2 Intermediate services
- L7.3 Intermediate technical
- L8.1 Employers (small)
- L8.2 Employers (agriculture)
- L9.1 Own account
- L9.2 Own account (agriculture)

Class III: Working

- L10 Lower supervisors
- L11 Craft and related
- L12.1 Semi-routine sales
- L12.2 Semi routine services
- L12.3 Semi routine technical
- L12.4 Semi routine operatives
- L12.5 Semi-routine agriculture
- L13.1 Routine services
- L13.2 Routine production
- L13.3 Routine operatives
- L14.1 Never worked
- L14.2 Long-term unemployed

Source: Rose, D. and O'Reilly, K. (1998), The ESRC Review of Government Social Classifications, London: Office for National Statistics and Swindon: Economic and Social Research Council.

APPENDIX VII
HOME APPLICANTS ACCEPTED TO ENGINEERING DEGREE COURSES BY DISCIPLINE 1992-2001

	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
General engineering	3,371	3,462	2,810	2,425	2,228	2,278	2,023	1,928	1,930	1,955
Chemical engineering	1,212	1,156	1,048	939	893	956	910	843	718	660
Civil engineering	3,265	3,157	2,752	2,438	2,166	1,925	1,820	1,682	1,614	1,625
Electrical engineering	1,447	1,295	768	154	144	119	97	100	102	91
Electronic engineering	3,216	3,212	2,953	2,452	2,593	2,651	2,440	2,417	2,427	2,579
Mechanical engineering	3,493	3,829	3,631	3,350	3,298	3,298	3,430	3,297	3,163	2,985
Aeronautical	887	896	902	885	914	986	1,058	1,140	1,255	1,327
Production/manufacturing	1,199	1,314	1,238	1,418	1,180	1,242	1,178	1,155	1,312	1,372

Source: Engineering Council *Digest of Engineering Statistics* and UCAS Annual Reports from http://www.ucas.ac.uk, statistical enquiry service

Notes to table

There has been a downward trend in applicants accepted since the early 1990s for all disciplines, with exception of aeronautical and production/manufacturing engineering. Over the ten-year period, acceptances to aeronautical engineering have steadily increased, while those to production/manufacturing have remained largely stable.

APPENDIX VIII

EU AND 'OTHER OVERSEAS'* STUDENTS AS A PERCENTAGE OF ALL STUDENTS ACCEPTED TO ENGINEERING DEGREE COURSES IN THE UK 1996-2001

	1996	1997	1998	1999	2000	2001
Chemical Engineering	32.2	29.9	27.9	23.0	26.7	29.8
EU and Other overseas (n=)	*(424)*	*(408)*	*(352)*	*(252)*	*(261)*	*(280)*
All students (n=)	*(1317)*	*(1364)*	*(1262)*	*(1095)*	*(979)*	*(940)*
Civil Engineering	32.7	38.7	36.6	35.9	35.3	31.2
EU and Other overseas (n=)	*(1052)*	*(1218)*	*(1049)*	*(942)*	*(879)*	*(737)*
All students (n =)	*(3218)*	*(3143)*	*(2869)*	*(2624)*	*(2493)*	*(2362)*
Electrical Engineering	42.9	48.7	54.5	47.1	47.2	48.9
EU & Other overseas (n=)	*(108)*	*(113)*	*(116)*	*(89)*	*(91)*	*(87)*
All students (n=)	*(252)*	*(232)*	*(213)*	*(189)*	*(193)*	*(178)*
Electronic Engineering	25.2	27.3	25.0	24.9	24.8	23.7
EU and Other overseas (n=)	*(874)*	*(998)*	*(814)*	*(801)*	*(800)*	*(800)*
All students (n=)	*(3467)*	*(3649)*	*(3254)*	*(3218)*	*(3227)*	*(3379)*
Mechanical Engineering	26.2	28.0	25.2	20.9	19.4	19.9
EU & Other overseas (n=)	*(1173)*	*(1280)*	*(1157)*	*(872)*	*(760)*	*(741)*
All (n=)	*(4471)*	*(4578)*	*(4587)*	*(4169)*	*(3923)*	*(3726)*

*EU applicants are those domiciled in the European Union (excluding UK). Non-EU students are coded as 'other overseas'.

Source: UCAS Annual Reports, from http://www.ucas.ac.uk, statistical enquiry service.

Notes to table

The proportion of EU and 'other overseas' students tends to be highest in electrical engineering at almost half the cohort of applicants accepted in 2001, and lowest in electronic engineering, at less than one quarter in 2001. The proportion of EU and other overseas students has remained largely stable in electronic engineering, with small variations during the five-year period in civil and electrical engineering (averaging approximately one-third and one half of applicants accepted respectively). In mechanical engineering, however, the proportion of EU and other overseas students shows a decline over the five-year period, from 26.2% in 1996 to 19.9% in 2001.

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Is Technology Masculine? Theorising the Absence of Women

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Abstract - **Why are women under-represented in engineering and other technological and scientific careers? Is technology masculine? If so, in which ways is it masculine? And is it possible to have 'gender-neutral' technology? This paper explores feminist theories of the gender-technology relation in order to answer these and other questions.**

Despite numerous initiatives since the 1970s to encourage girls and women into professional careers in engineering in the UK, these occupations have remained overwhelmingly dominated by men. In 1997, women comprised only 11 per cent of UK undergraduates applying to the 'engineering and technology' subject group [1]. Italian women appear to be under-represented in these areas in similar proportions to British women. In the 1990-91 academic year, the proportion of female students in the category 'engineering studies' was 10.8% and 12% for Italy and the UK respectively [2]. There is considerable variation amongst individual disciplines, but it is fair to say that, of all scientific and technological fields, engineering contains the smallest proportion of females. Moreover, women's absence from engineering can be seen as a *global* phenomenon. An analysis of twenty-four major countries covering the regions of Europe, America, Asia, Africa and Oceania undertaken by the United Nations Educational, Scientific and Cultural Organisation (UNESCO) in 1988 concluded that 'the under-representation of women in scientific and technical disciplines is virtually universal' [3]. How then, do we explain women's absence from engineering and, indeed, from careers in technology and science more generally?

Is technology masculine?

One of the arguments commonly used to explain women's absence from technology is that it is 'masculine'. Indeed, Rosalind Gill and Keith Grint have claimed that the assumption that technology is associated with masculinity underpins most theories of the gender-technology relation [4]. The current paper explores feminist perspectives on the association between technology and masculinity, before asking whether a 'gender-neutral' technology is possible. Feminist theories of technology have been developed from earlier studies on the 'problem' of women and science. However, Judy Wajcman argues that much feminist theory too easily conflates science and technology, when in fact they are 'distinguishable sub-cultures in an interactive symmetrical relationship' [5]. Nonetheless, because science and technology *are* closely related, many feminist texts on 'women and science' implicitly include engineering and computing in their analyses. (See, e.g., [6]-[8].)

Whilst most feminist theorists agree that technology and masculinity are *associated*, they differ as to the nature and origin of this association and consequently, on whether and how it might be changed. Two main ways of conceptualising the 'masculinity of technology' can be identified, one which treats masculinity as an *image*, and the other which sees masculinity as *intrinsic* to technologies [9]. In the first of these perspectives, technology itself is gender-neutral. Here, the masculinity of technology is an image – a false, or distorted view of technology (which can presumably be corrected). This view is characteristic of the liberal feminist tradition, which has been concerned to explore the reasons why technology is seen as masculine and suggest ways in which the image can be changed in order to encourage more women to take up careers in technology. Arguably, one of the reasons that occupations such as engineering have a masculine image is because it is predominantly men who do them. In terms of numbers, it is males who study, teach and go on to pursue professional careers as engineers, scientists and technologists [10], [9]. The masculine image of these occupations is said to be further reinforced by the ways in which science and technology are presented in the classroom and represented in educational curricula in ways which exclude girls' experience and world views [9]. Arguably,

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this masculine image discourages girls from taking options in physical science and technology at secondary school, which then blocks their entry into scientific and technical careers [11]. In support of this argument, studies have shown that some subjects, such as physics, mathematics, computing and electronics, have a masculine image which girls and boys understand and act upon [12]-[15].

Much of the early research on girls and science took a 'psychologistic approach', examining individual factors, such as personality and ability, to explain girls' 'avoidance' of science at school [9]. Women's problematic relationship to technology and science was seen to be a consequence of their (mistaken) perception of these areas as masculine. Consequently, many of the ensuing strategies and initiatives set out to address what they termed the 'underachievement of girls' in science education, and to correct their misconceptions about science. One objective was to attract girls and women into courses and careers in science and engineering by raising their awareness of the opportunities they were missing [16]-[20]. This approach is exemplified in the GIST (Girls into Science and Technology) and WISE (Women into Science and Engineering) campaigns in the 1980s. Flis Henwood describes the WISE campaign as 'focused on women's 'choices', which it understands as being constrained both by a lack of information about scientific and technological work and by a masculine image of science and technology' [21].

Later scholarship, still broadly within a liberal feminist perspective, moved away from individual approaches to examine more structural explanations for women's under-representation in these areas. The 'socially constructed' aspects of science and technology were emphasized and researchers began looking beyond girls' and women's personalities, abilities and 'choices' to the social 'barriers' preventing their participation in these areas. Such barriers have been identified at both the structural and the symbolic levels, and are seen to result from cultural beliefs and practices. Structural barriers include institutional and organizational practices and policies which explicitly exclude women, or restrain their access or involvement [22]. Other, more symbolic barriers, function less overtly to discourage girls and women from, or cause them to reject occupations like engineering. One example is the way the dominant gender ideology shapes attitudes. This ideology dictates what is appropriate or 'natural' work for men and women, in turn reinforcing the stereotype of engineering as an activity appropriate for men. These cultural beliefs are said to be reproduced through socialisation practices in the family and school, and have the effect of discouraging girls from studying the subjects necessary for occupations like engineering and from pursuing careers in these professions, which are seen as masculine [23].

For liberal feminism then, the 'problem' of women and technology has typically been seen as one of access and the solution is seen to lie in changing socialisation processes and equal opportunities policies [5]. Liberal feminism has had an enormous influence on social policy initiatives and as Sue Rosser has argued, its goals and objectives underpin the majority of the US National Science Foundation's programmes for women and science to this day [24]. However, this approach has been criticized for its tendency to 'blame' girls or their parents [8], since their socialization is seen to be 'lacking' in some respect and in need of correction to help girls and women enter technological education and careers. For this reason, some have termed this solution to the problem the 'deficit model' [25], [8]. Furthermore, feminists from other theoretical traditions accuse this approach of conservatism, since it requires women to adjust to the existing technological order, without proposing similar changes in either men or technological institutions. These feminists argue that it is not the *image* of technology which needs to be changed, but technology itself.

Whereas liberal feminism has tended to treat the technological sphere as gender-neutral, albeit conventionally dominated by men [26], other feminist perspectives argue that technology is *gendered*. Here, the widely accepted association between technology and masculinity changes from one of image, to the view that technology is *inherently* masculine. These analysts challenge the idea that technology simply shapes gender relations without being shaped *by* them [4]. Far from being neutral, technology is seen to be 'shaped' by social interests, including those of gender. Since women have traditionally been absent from technology, technological knowledge, practices and artefacts are therefore seen to embody 'masculine values' [5], [4], [26].

Eco-feminism is a form of feminist thought which sees technology as not only gendered, but essentially and inherently *patriarchal*. Eco-feminism, as defined by Cat Cox, 'draws together environmental, feminist and women's spirituality movements; it describes the diverse range of women's efforts to save the Earth from ecological disaster and incorporates a new feminist view of women and nature' [27]. Eco-feminism was inspired by the 'difference feminism' of the early 1980s, which revalued qualities that our society had devalued as "feminine", such as subjectivity, co-operation, feeling and empathy [28]. Eco-feminism asserts that women's capacity to give birth makes them closer to nature and inherently pacifist and nurturant. It has focused particularly on reproductive technology, military technology and the ecological effects of other modern technologies [5]. At its most extreme, eco-feminism states that Western science and technology embody patriarchal values and are used by men to dominate and control both nature and women [5], [4]. Maria Mies and Vandana Shiva articulate the central tenets of eco-feminism in the passage below:

> The new developments in biotechnology, genetic engineering and reproductive technology have made women acutely conscious of the gender bias of science and technology and that science's whole paradigm is characteristically patriarchal, anti-nature and colonial and aims to disposses women of their generative capacity as it does the productive capacities of nature [29].

The eco-feminist position has usefully highlighted the ways in which technology has been used 'to oppress those who do not possess it or cannot engage with it' [30]. However, it has been subjected to a powerful critique by those wishing to develop more productive engagements between feminist politics and the technological [31]. Eco-feminism is accused of reinforcing the association between technology and masculinity, by accepting dualist categories of women and nature and men and technology [26]. This perspective also reduces women to their sexual and reproductive capacities and reinforces a stereotype of 'female nature' which has oppressed women for centuries. Heavily reliant on a notion of 'patriarchy' which essentialises men, eco-feminism cannot account for the differences between men, forms of masculinity and their relationships to technology. Rather, according to Wajcman, it has a tendency to treat technology as a set of neutral artefacts manipulated by men in their own interests [5]. Furthermore, eco-feminism conflates technology and patriarchy to such an extent that they become one and the same thing and the only strategy open to eco-feminists is to reject technology altogether [4], [30]. Malcolm Williams has argued that this form of rejectionism is naive, because it assumes that it is both desirable and possible to return to a pre-technological age. It is also incoherent because it rejects some forms of technology, such as its military uses, whilst presumably wanting to retain others, such as preventative vaccines or communications technology [32]. Moreover, this response is politically disabling for feminism, since it leaves the technological power in men's hands. Much current feminist theory therefore distances itself from the 'technophobia', underpinning the eco-feminist view, reminding us that technology can be liberating as well as oppressive for women.

A third feminist perspective on technology is known variously as 'socialist feminism', 'feminist constructivism', and 'technology as masculine culture' [4], [26]. These theorists share with eco-feminism the view that technology is gendered, but reject the essentialism, pessimism and separatism of this position, remaining committed to improving women's situation within existing science and technology. However, they also differ from the liberal feminist approach in arguing that assimilationist strategies are insufficient - existing technology and its institutions must change. Socialist feminism focuses on gender-technology relations in the context of industrial technology. It draws on historical insights and the interplay of patriarchy and capitalism to explain how men came to dominate and women came to be excluded from technological knowledge and skill during industrialisation [26]. These feminists have also pointed out that the very definition of technology has a male bias. This is because what counts as technology has tended to exclude women's activities and inventions [33], [5], [4]. In response, feminist historians have reclaimed women's rightful place in technology by documenting the ways in which women who contributed to technological developments have been 'hidden from history' [34], [5], [20]. Some have argued that before the industrial revolution, women were active participants in technological invention and innovation, but became excluded from technology as a consequence of the gendered division of labour which followed the mechanisation of production. These authors claim that when the spheres of paid work and home became separated, women were consigned either to the least skilled jobs, or to the domestic sphere [12], [26], [5]. For Jan Wajcman, who is a key contributor to the 'technology as masculine culture' perspective, 'the enduring force of the identification between technology and manliness, therefore, is not inherent in biological sex difference. It is rather the result of the historical and cultural construction of gender' [5]. For these theorists then, both technologies and gender structures are the outcomes of social arrangements, with their roots in past human practice [26]. Here, technology is treated as a culture with its own knowledge, values, beliefs, practices, styles of interaction and codes of language and dress. For Wajcman, this culture is one which 'expresses and consolidates relations amongst men', so much so that 'technical competence is an integral part of masculine gender identity', therefore it should be no surprise that women do not aspire to it [5].

This perspective, like that of liberal feminism, allows for the possibility of change through political intervention. However, in asserting that both technology *and* gender are socially constructed, it challenges liberal feminism's belief that women's under-representation in engineering is simply due to a lack of access to education, training or employment, or the effects of sex-role stereotyping. It also challenges the eco-feminist view of innate differences in values between the sexes. Moreover, by employing historical analysis, it is able to describe the specific ways in which technology became associated with men and masculinity [26]. However, Gill and Grint argue that whilst the 'technology as masculine culture' perspective is more sophisticated than both liberal and eco-feminist positions, there are still some limitations. They point out that this perspective employs inconsistent uses of concepts such as 'patriarchy' and 'ideology'. Terms like 'patriarchy', 'masculinity', and 'men' are used interchangeably, which allows theorists to 'explicitly disavow and yet implicitly draw upon essentialist accounts of the gender-technology relation'. Similarly, they argue, theorists will sometimes use a notion of 'ideology' to which both men and women are seen to be subjected. This ideology attributes the gendering of technology to 'some bigger structure, such as 'masculinity' or 'patriarchy' which transcends individual men'. However, at other times this notion of ideology is not used and men are depicted as simply acting in their own (male) interests' [4]. As Wajcman herself admits, feminists have to tread the path between adopting an essentialist position that sees technology as inherently patriarchal, or losing sight of the oppressive structure of gender relations through an overemphasis on the variability of the categories of 'men', 'women' and 'technology' [5].

Is a gender-neutral technology possible?

Underpinning the belief that a gender-neutral technology is possible, is the widely held view that the presence of more women would somehow change existing 'masculine' technology. Most feminists (and many non-feminists) share the belief that women can 'make a difference' to existing technology at some level. One way in which women have been expected to make a difference to engineering is simply in terms of their numerical presence. For example, 'critical mass' theory has been popular with liberal feminists and others concerned with equal opportunities, who believe that once a certain proportion of women have become engineers, the masculine image of engineering will disappear. Some take the argument further, suggesting that these institutions will also change qualitatively in culture, content and method, because the presence of a larger number of women creates the opportunity to reshape gender relations [28]. Others disagree, arguing that whilst it may be true that women and other minority groups entering education and careers in engineering may *themselves* benefit from the presence of "others in the same boat", this in itself is not sufficient to change the practice of engineering [35]. Londa Schiebinger, for example, claims that women's potential role as agents of change has been over-emphasized. As she points out, 'many women who enter science have no desire to rock the boat' [28]. Judith Glover supports this view, arguing that there has been a mistaken assumption that women scientists or engineers automatically hold feminist values [8].

Therefore, rather than seeing *women* as the agents of change, many commentators have argued that it is *feminists* who can make a difference to science and technology. This is because, as Shiebinger claims, the simple equating of women entering science with a change in science has ignored the crucial role of feminist politics [28]. Feminists have devoted many years to establishing critiques of science, which claim in various ways that scientific knowledge is influenced by gender. All feminist critics view women's historical exclusion from science as significant in the gendering process, but some locate the 'masculine bias' in the culture and institutions of science, whilst others take it further, suggesting that the content and methods of science are also masculine. These are contentious arguments and raise a number of issues which cannot be explored here. To assess this claim, it would be necessary to examine the different disciplines of science and technology individually. Whilst feminists have presented plenty of evidence to suggest that gender interests have influenced the content of the 'life sciences' such as medicine, biology, primatology and archaeology, are there concrete examples of gender bias in the substance of physics, mathematics or engineering? [28]. Gender assumptions have organized scientific agendas, theories, priorities and outcomes in the life sciences. One example of this is the way in which women have been omitted as subjects of medical research from large and influential studies, which have been conducted exclusively on men [28]. Can we find similar examples of such gendering in the physical sciences as those in the life and social sciences? Feminism already has begun to do this by pointing to the ways in which the definitions of technology and engineering have excluded the feminine. If, as seems feasible, we can assume that the *culture* of engineering is masculine, we need to ask where the distinction lies between the culture of engineering and its *content*. We also need to identify the ways in which that masculine culture influences and 'biases' the content of engineering, in terms of its agenda, research priorities, even principles of measurement. In short more work must be done to investigate which aspects of engineering are masculine.

So is a gender-neutral technology possible? For eco-feminists the answer is no. Technology is inherently patriarchal and the political task is to reject it, or perhaps develop a separate 'feminine' technology, based on 'women's values'. The futility of this approach has already been discussed. For liberal feminists, the answer appears to be yes, if we can assume that increasing the representation of women in technological education and employment is to count as gender-neutral technology. If, however, as has been argued above, social interests and values, including those of gender, inevitably shape technology, then a gender-neutral technology is not possible. Rather, we should question the origins of the so-called 'masculine' and 'feminine' values and decide which of these should be accepted or rejected in order to create a more egalitarian technology.

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Civil engineering's image in schools—and how to change it

Applications to study civil engineering at British universities halved between 1995 and 2001, reflecting the profession's declining attraction as a career. This paper reports on a study of school and college students to discover why. It concludes that the problems which need to be addressed include the 'invisibility' of the profession, the absence of positive role models, low starting salaries and unattractive working conditions.

In September 2001 it was reported[1] that applications to university to study civil engineering had fallen by 50% since 1995 (Figs 1 and 2). This decline appears to be continuing as early indications from the Universities and Colleges Admissions Service (UCAS) show that 2002 applications to civil engineering courses were down by around 5% and to building/construction courses by 9% compared to the previous year.

Between 1993 and 2000 the number of home students accepted on to civil engineering degree and HND courses fell from 3157 to 1614 and from 701 to 132 respectively.[2] Despite some improvement in the quality of applications to civil engineering degree courses after 1996, around

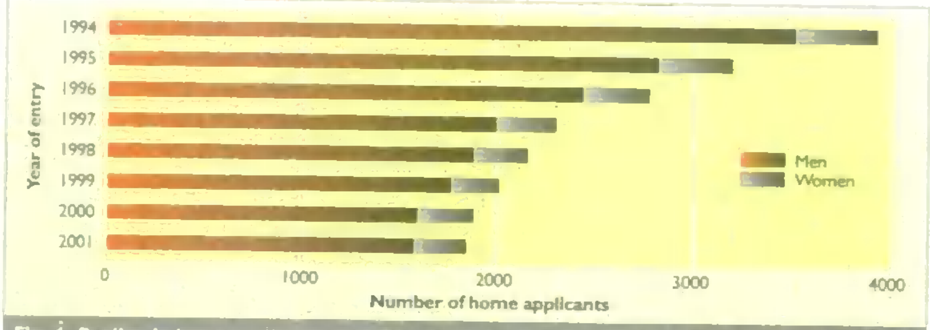


Fig. 1. Decline in home applicants to UCAS for civil-engineering (H2) by year of entry and gender.[21] The use of applicant data is preferable to applications since applicants made a varying number of applications

Table 1. Year 12 students' first choice of career by gender.[5] For example, 55 students (13·8% of the respondents having a career plan) chose teaching. Of these, 10 were male and 45 female, representing 5·5% and 20·7% of the males and females respectively. In Table 4 females rated highly self-fulfilment and the chance to help others, so women often opt for careers in teaching and nursing, as below. Note below that of the valid questionnaires, 32% of males and females had 'no career plan'.

Numbers are given, with the percentage in brackets			Gender of respondent	
	Career	Total: No. (%)	Male: No. (%)	Female: No. (%)
1	Teaching	55 (13·8)	10 (5·5)	45 (20·7)
2	Armed forces	28 (7·0)	23 (12·7)	5 (2·3)
3=	Business	23 (5·8)	13 (7·2)	10 (4·6)
	Engineering	23 (5·8)	22 (12·2)	1 (0·5)
	Entertainment/performing arts	23 (5·8)	8 (4·4)	15 (6·9)
6	Computer-related work	21 (5·3)	20 (11·0)	1 (0·5)
7	Art, design and graphics	20 (5·0)	10 (5·5)	10 (4·6)
8	Science-based work	19 (4·8)	9 (5·0)	10 (4·6)
9	Emergency services	18 (4·5)	12 (6·6)	6 (2·8)
10	Nursing	16 (4·0)	1 (0·6)	15 (6·9)
11	Animal-related work	14 (3·5)	5 (2·8)	9 (4·2)
12=	Personal services (e.g. beautician)	13 (3·3)	0	13 (6·0)
	Sport-related work	13 (3·3)	9 (5·0)	4 (1·8)
14=	Child-related work	12 (3·0)	0	12 (5·5)
	Law	12 (3·0)	2 (1·1)	10 (4·6)
	Media	12 (3·0)	5 (2·8)	7 (3·2)
17	Tourism	11 (2·8)	3 (1·6)	8 (3·7)
18	Social work/care	9 (2·2)	1 (0·6)	8 (3·7)
19	Medicine and dentistry	8 (2·0)	3 (1·6)	5 (2·3)
20=	Languages	6 (1·5)	2 (1·1)	4 (1·8)
	Psychology/counselling	6 (1·5)	2 (1·1)	4 (1·8)
22=	Architecture/construction	5 (1·3)	4 (2·2)	1 (0·5)
	Clerical and administrative	5 (1·3)	1 (0·6)	4 (1·8)
24=	Catering	2 (0·5)	2 (1·1)	0
	Craft/trades	2 (0·5)	2 (1·1)	0
Other/unable to classify		22 (5·5)	12 (6·6)	10 (4·6)
Sub total		398 (100)	181 (100)	217 (100)
Students claiming 'no career plan'		188 (32)	87 (32)	101 (32)
Missing due to item non-response		20		
Total		606		

nine out of 58 courses lost accreditation or closed between 1990 and 2000. There is now concern about skills shortages and the lack of suitably qualified civil engineers. Other areas of engineering have also proved less popular, with reports of 'engineering in crisis'.[3]

What young people think

Within the civil engineering profession, opinions vary as to what, if anything, should be done to address the 'crisis'. Some advocate engaging with school children to ensure that civil engineering has a high profile and a positive image. Others advocate doing nothing, so the scarcity of graduates will lead to higher salaries and attract better-qualified students into the industry. During this debate the opinions of school and college students are often ignored, but it is their perception of the profession and their career choices that will determine application numbers for the next decade. By having a better understanding of the image of civil engineering in schools, it should be easier to devise a strategy for the future.

This paper summarises parts of a larger study of young people's career intentions and attitudes towards engineering.[4,5] One approach involved marketing specialists from the University of Plymouth Business School, who ran focus groups with BTEC National Diploma and A-level (year 12/13, 16–18-year-old) students from Devon, Dorset, Somerset and South Wales. All had the potential to study engineering if they wished.

A second approach involved analysing 606 questionnaires from year 12 students in local education authority maintained co-educational comprehensive schools in Plymouth and Bristol. This represented 91% of the available schools and about 43% of the student population. The results form the basis of Tables 1–4; the number of respondents varies as some questions were unanswered.

Additionally, contact with over 3000 school students in Devon and Cornwall through recruitment activities has provided background information that has contributed indirectly to the paper. Research conducted elsewhere is also used below to explain how the image of civil engineering is formed and what could be done to improve it. Clearly, part of the solution is to highlight civil engineering's most attractive features. However, it is the less attractive features that are considered here since they are responsible for creating the negative image that results in school students discounting engineering as a career.

How an occupation's image form

By late primary school age most pupils have already rejected many jobs on the basis of their perceptions of how interesting and enjoyable they are and the

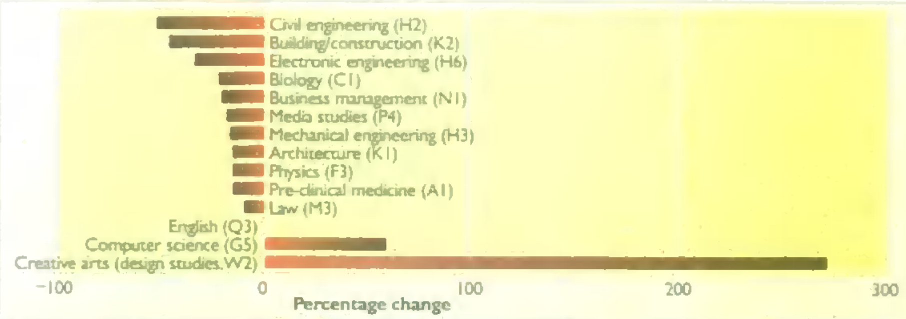


Fig. 2. Percentage change in home applicants to selected subject groups between 1994 and 2000 entry.[21] Note that it is not possible to show the increase in sports science (B6) or tourism (P7) because no applications were recorded under these headings in 1994 (see Fig. 3)

estyle that goes with them.[6] These per-
ptions are often based on their own
servations and images obtained from
e media, friends, teachers and parents.
amily role models are particularly influ-
itial in this process. Studies have found
at more than half of those intending to
llow engineering or science careers had
relative, usually a father, who was work-
g as an engineer.[5,7]

At their early, formative stages children can gain an (imperfect) idea of what a job involves through personal contact, albeit limited. Exposure to someone doing a job, such as a teacher, can create a lasting impression that influences ultimate career choice (Table 1). However, most children never meet a professional engineer whose work is intellectual and office-based, thus this aspect of the profession is 'invisible'.

Additionally, at present, engineering is not directly taught in schools and in this sense is also invisible, unlike physics, biology, English and other core subjects that receive more university applicants (Fig. 3). A lack of knowledge of a job or profession often results in it being dismissed as a career option (Table 2). In a MORI poll of 11–16-year-olds, over half of those who said they knew nothing about engineering thought it boring, compared to 11% of those who claimed to know a great deal about it.[7]

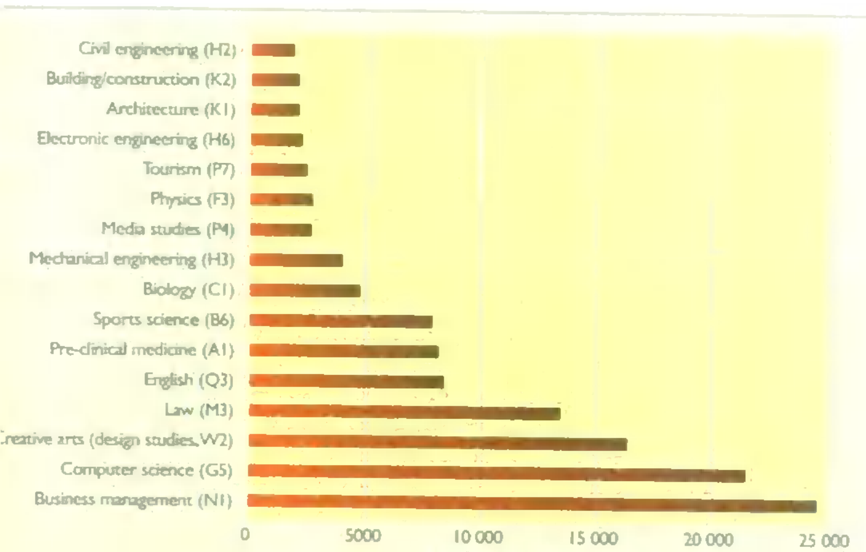
Most careers education and guidance programmes start in upper secondary school and often provide information solely on those occupations that students ask about. Therefore occupations which are invisible or perceived to be unattractive are ignored.

ble 2. Likelihood of considering engineering by level of knowledge.[5] For example, 377 respon-
ents said it was very unlikely, of which 47·6% knew nothing at all about engineering. Lack of
owledge corresponds to engineering being an unlikely career, whereas knowledge makes it more
kely. The data cannot show if knowledge leads to the decision to be an engineer, or if those
anning to be an engineer seek information about it. Note: due to item non-response, 39 question-
ires were unusable

kelihood of becoming engineer		Level of knowledge about engineering: (%) Nothing at all	Not much	A little	Quite a lot	A lot
ry unlikely	(377)	47·6	35·1	14·1	2·1	1·1
irly unlikely	(101)	4·9	43·6	31·7	14·9	4·9
irly likely	(44)	6·8	9·1	36·4	36·4	11·3
ry likely	(45)	6·7	6·7	20·0	44·4	22·2

ble 3. Likelihood of becoming an engineer by gender.[5] It is assumed below that unlikely = very
likely + fairly unlikely from Table 2, and similarly that likely = fairly likely + very likely.

kelihood of becoming an engineer		% all	% males	% females
likely	(478)	84·3	70·1	96·4
ely	(89)	15·7	29·9	3·6



. 3. The number of home applicants to UCAS for entry in 2000 to selected subjects. Subjects
eady taught in schools fare better than civil engineering[21]

Mixed views on engineering

In the UK, any occupation with 'engineering' in its title has a dual image. As Macdonald[8] pointed out

> 'In a society which discerns no major difference between the mechanic and the graduate engineer, engineering itself has long suffered from a metal-bashing image.'

One image of engineering often held by young people is of car mechanics and dirty, manual, low-status work sometimes associated with apprenticeships. About 54% of 11–16-year-olds associate engineering with dirty working conditions,[7] making it unattractive to many boys, and to girls who feel they would have to cross gender boundaries in low-status occupations (Table 3). Of the students who are interested in engineering, many leave school at age 16 and do not achieve graduate status. Table 1 shows that a third of 17-year-olds have no career plans, despite having already selected their post-16 subjects. Hodgkinson[5] found that some potential engineers were taking GNVQs in leisure and tourism, about three-quarters were taking one or more A-levels, but crucially only one-third were taking A-level mathematics. Thus there is frequently a discrepancy between those interested in engineering and those studying appropriate subjects.

A second image of engineering, typically held by sixth form students (year 12/13), is of the professional engineer who designs aeroplanes and space shuttles. However, they still perceive engineering as having a physical as well as intellectual element.[6] These older students' work goals are now more materialistic, with pay, job satisfaction (interest/enjoyment) and security of employment being rated as important (Table 4). Occupations that are not well paid, which can include engineering, suffer as a consequence.

Frequently, A-level mathematics and science are associated with professional engineering (Fig. 4), and both are regarded as difficult and not very interesting.[9] In 2001 it was predicted that the high failure rate of 29% in the 'new' AS-level maths would result in about 20% fewer students taking the A-level the following year, with potentially serious consequences for mathematics and engineering courses.[10] Added to this, mathematics is a crucial 'filter' for girls, who tend to drop the subject after GCSE and are therefore under-represented in A-level passes.[11] To avoid mathematics and science, many male students apply for courses in computing or information technology where maths and science are not required or where it will be easier to cope, and where there may also be higher salary and career prospects.[9]

Civil engineering's image

In Foskett and Hemsley-Brown's study[6] of students at age 10, 15 and 17, the main reasons for dismissing engineering as a career were

- not interested (27·1%)
- dirty work (12·7%)
- don't like science (11·2%)
- too difficult (7·3%).

Traditionally, many see construction as a dirty, manual job. A report produced in 1989 for the National Contractors Group of the Building Employers Confederation[12] claimed that

> 'Few people and organisations in the construction industry had taken the issue of image sufficiently seriously... There is no clear distinction between

they still perceive engineering as having a physical as well as intellectual element

Table 4. Most important factor in a job or career by gender.[5] Students were asked: 'Which five of the items below would be most important to you in a job or career? Please list five items, then rank your chosen five in order of importance, where 1 = most important and 5 = fifth in importance.' The table summarises the responses ranked first. For example, 151 students (27.8% of the valid responses) rated good money as most important. Of these, 92 were male and 59 female, that is 36.3% and 20.3% of the males and females respectively.

Numbers are given, with the percentage in brackets			Gender of respondent	
	Factor	Total: No. (%)	Male: No. (%)	Female: No. (%)
1	Good money	151 (27·8)	92 (36·3)	59 (20·3)
2	Self-fulfilment	94 (17·3)	30 (11·8)	64 (22·1)
3	Chance to help others	46 (8·5)	8 (3·2)	38 (13·1)
4	Excitement	42 (7·7)	23 (9·1)	19 (6·6)
5	Job security	39 (7·2)	16 (6·3)	23 (7·9)
6	Ability to combine career and family	35 (6·4)	17 (6·7)	18 (6·2)
7	Chances for advancement	33 (6·1)	20 (7·9)	13 (4·5)
8	Variety	19 (3·5)	11 (4·3)	8 (2·8)
9	Contact with other people	17 (3·1)	3 (1·2)	14 (4·8)
10	Status and respect from others	15 (2·8)	8 (3·2)	7 (2·4)
11	The challenge of difficult work	13 (2·4)	8 (3·2)	5 (1·7)
12	To make my own decisions	11 (2·0)	6 (2·4)	5 (1·7)
13	Outdoor environment	10 (1·8)	3 (1·2)	7 (2·4)
14=	To become famous	8 (1·5)	6 (2·4)	2 (0·7)
	Other	8 (1·5)	1 (0·4)	7 (2·4)
16	To make things	2 (0·4)	1 (0·4)	1 (0·4)
	Sub total	543 (100)	253 (100)	290 (100)
	Missing due to item non-response	63		
	Total	606		

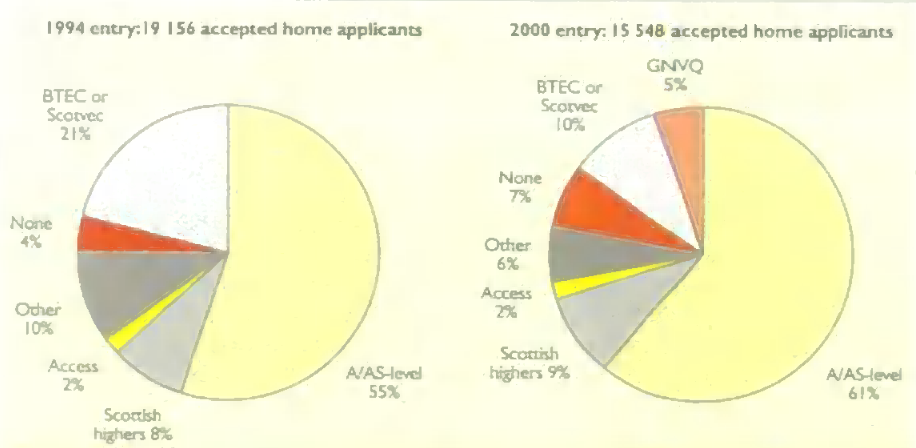


Fig. 4. Main qualifications of accepted home applicants to engineering and technology degree courses in 1994 and 2000 show how A-levels dominate but that GNVQs have undermined BTECs[21]

the starting salary in civil engineering remain among the lowest of all professions, being £850 lower than average.

the hairy-arm, cowboy bungalow extension builder and the major contractor offering a sophisticated, total capability... there is still ignorance and prejudice about the construction industry in schools. The industry is still seen as male-dominated and hostile to female career entrants.'

The image of a male-dominated industry still discourages many girls (and some boys) from considering it as a career. In 1994 only 11% of home applicants to civil engineering were women, rising to 15% in 2000. This gender imbalance is apparent from Fig. 5 and Table 3.

Civil engineering's image problems have always existed but have not deterred people (mostly men) from entering the profession in the past. On the contrary, in 1987 the ICE suggested that the oversupply of graduates was depressing salaries and adversely affecting the profession's image.[13] An illustration showed graphically that civil engineers had a salary of £20 000 per annum compared to police at £24 000, doctors £27 000 and MBAs £37 000. The ICE recommended a reduction in the number of accredited courses, UK graduates and chartered civil engineers and reported that

'many of the best and most promising graduates have left civil engineering for other fields or indeed do not now join the construction industry.'

This is still the case. In 2001 the Association of Graduate Recruiters found that at £18 150 a year, the starting salary in civil engineering remain among the lowest of all professions, being £850 lower than average.[14] This is important in an occupation which primarily attracts males, who rank good pay among their most important work goals (Table 4). Another survey[15] reported

- an even lower £16 500 average starting salary
- 82% of respondents thought they were undervalued by their employer
- 75% said they were overworked
- 64% had considered leaving the industry in the last year
- 53% were looking for a new job
- 84% said the skills shortage should be addressed through higher salaries.

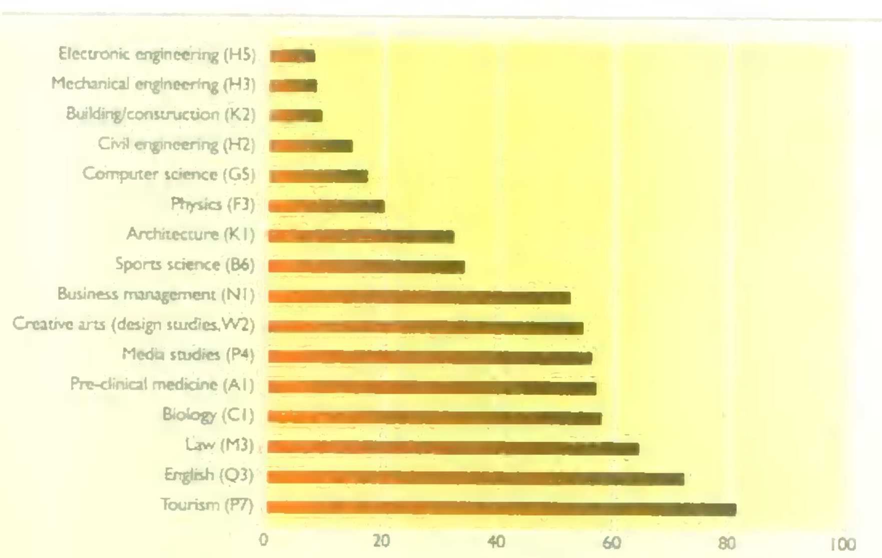
Thus for over a decade the image has been of a poorly paid industry with staff retention problems. Many civil engineers are dissatisfied with the profession, which does not help promote a positive image to those in schools where civil engineering often has either a negative image or no image at all as a result of being 'invisible'. Based on 3134 questionnaires completed by sixth form students, Winter[16] found that

'as many as 70% claimed to 'know nothing' about civil engineering/construction and, presumably at least in part as a consequence, 62% would not consider it as a career.'

Despite the construction industry being one of Britain's largest, civil engineering (H2) and building/construction (K2) attract a relatively small number of university applications (Fig. 3). Apparently, civil engineering's perceived image is not compatible with the aspirations of most school students.

How the image is created

Research for the University of Plymouth using word-association tech-



ig. 5. Percentage of home applicants to UCAS who were women: selected subject groups, 000 entry[21]

niques in focus groups of potential engineers (therefore mostly male) found that there is a positive–negative image continuum along which the mainstream branches of the engineering profession are placed.[4] Increasingly, it seems, males do not want dirty jobs. At the positive end of the continuum are clean, professional, high-tech, exciting, modern disciplines with good graduate employment prospects. The negative end is associated with dirty, manual, boring, old-fashioned activities with, at best, patchy opportunities for employment and career advancement. Thus

- positive: anything associated with computers, electronic engineering, electrical engineering and mechanical engineering
- negative: construction/civil engineering.

The 1997 ranking reflects a male bias and their perception that computers are the future. Courses involving computing were viewed positively. This may partially explain why computer science has grown in popularity (Fig. 2), although mostly with men (Fig. 5). Computers, and mobile phones, are based on electronics, so electronic engineering was given a relatively high ranking. The word 'construction', which was often familiar from activities involving the Construction Industry Training Board (CITB), was usually viewed negatively and associated with basic 'brickies', low status, the 'easiest' type of course and environmental destruction. Civil engineering was frequently described as 'mega old-fashioned' and 'boring' because it was thought that most bridges, dams and roads had already been built, so future engineers would be left with only 'boring maintenance'.

The attitudes of many teenagers are formed by the media and their peer group. In the 1980s and early 1990s the prestigious Thames Barrier and Channel Tunnel projects gave civil engineering a positive media image, which was subsequently tarnished by environmental protests (e.g. Twyford Down and Newbury). In 1997 a civil engineering student at Plymouth investigated the image of the profession and identified a lack of positive role models. At the time the exploits of the eco-warrior, Swampy, were reported regularly by the media. In a small survey conducted by the student, 60% of school pupils supported Swampy and his fellow protestors, 20% did not and 20% were not sure. It was felt that the counter view to Swampy's was not well presented and that there were no well-known personalities to put the case for the civil engineering profession, either on environmental or other matters. This imbalance was noted by the National Contractors Group,[12] which highlighted the success of the contemporary Channel 4 programme, *Skyscraper*.

To summarise, factors which have contributed to the decline in civil engineering applications are as follows:

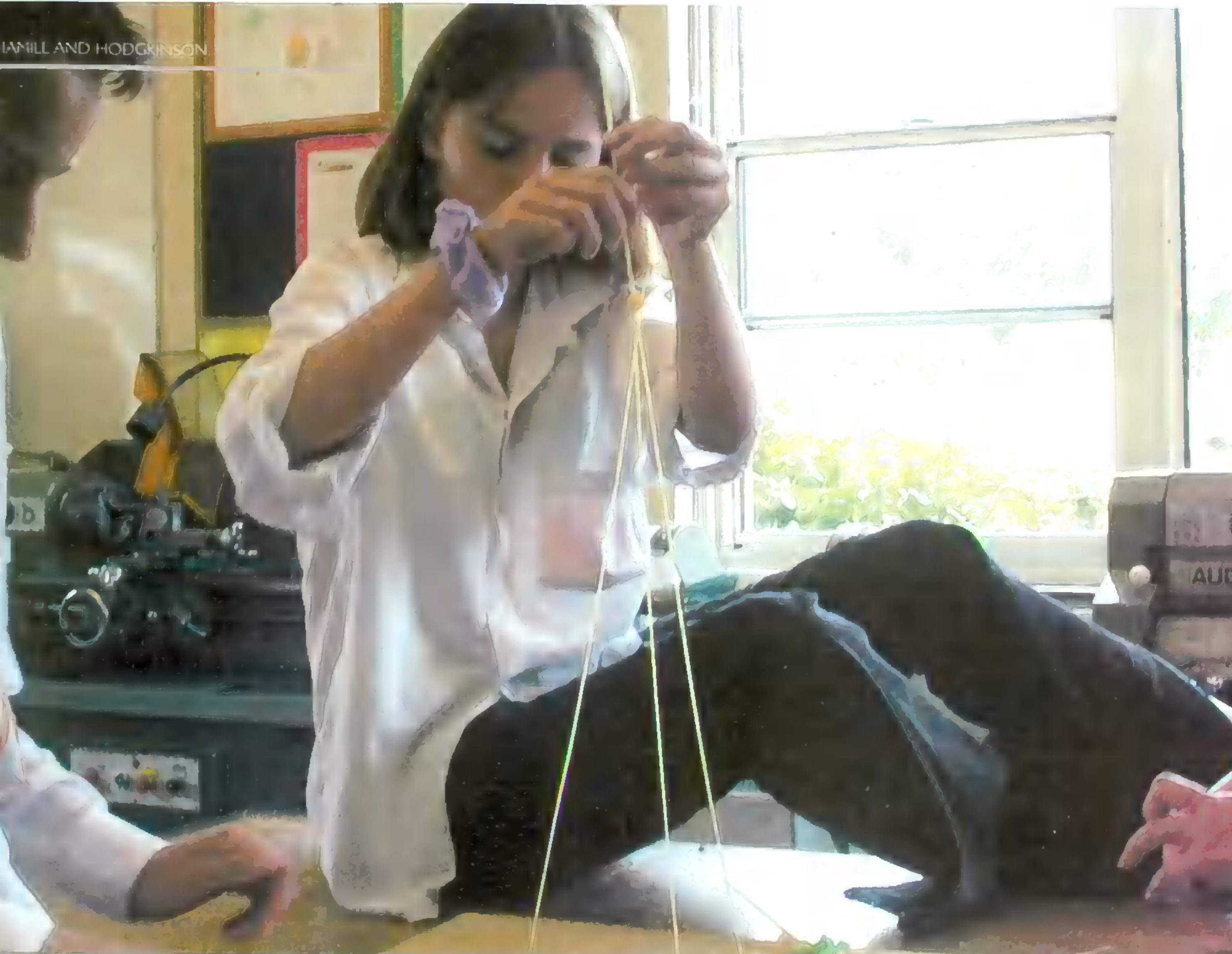
- Many professions compete to recruit from the same pool of well-qualified school students, so civil engineering's invisibility and image problems are a disadvantage.
- There is increased competition in the form of new and 'interesting' university courses such as sports science and tourism (Figs 2 and 3).
- The replacement of the respected BTEC National Diploma with the weak Advanced GNVQ reduced progression from colleges to university (Fig. 4).
- The perceived difficult, mathematical nature of civil engineering courses: 96% of university civil engineering departments say students' grasp of maths is inadequate, over half of students struggle to get a grip on structural engineering, and 55% of first-year students need remedial maths coaching.[17] This is not conducive to undergraduates recommending civil engineering to siblings and friends.
- Dissatisfaction within the profession, which discourages others from entering.

What can be done

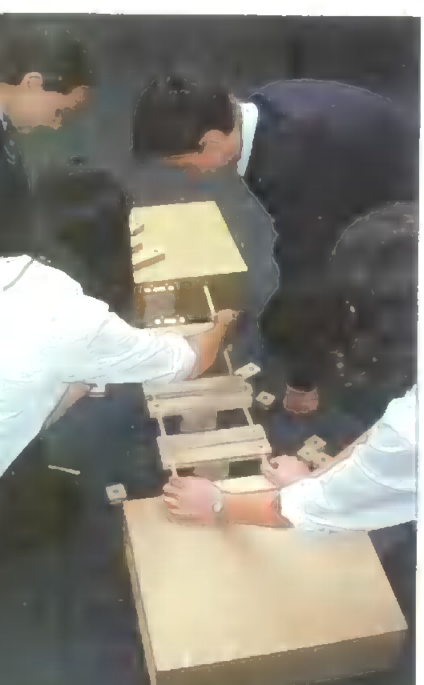
The ICE is to be commended for producing publicity material for 15–18-year-olds, such as NCE*insite* and *Edifice*. However, many jobs are rejected at an early age, so there is a strong case for producing publicity material and organising events for much younger pupils.[6] At the very least, opinions of engineering need to be shaped before students drop essential subjects, such as A-level mathematics. Some other suggestions are given below.

Image—must be based upon reality. There is little point trying to change civil engineering's image if it really is a relatively poorly paid profession with a culture of long hours, poor working conditions and slow career progression. Many, or most, school students are cynically astute and reject marketing hype. In the ICE magazine survey summarised above, 84% said that the skills shortage should be addressed through higher salaries. Graduates' salaries have increased, but compression of the pay scales can contribute to the dissatisfaction of more experienced staff. One recent article in the magazine concerned 'unsustainably low' consultants' fees and possible solutions,[18] while another regretted the loss of the HNC/HND route to corporate membership. There are many capable HND and BSc(Hons) students as a result of Sartor 3, yet some companies almost exclusively recruit more expensive BEng(Hons)/ MEng(Hons) graduates who can become CEng. It is important that all engineers are employed on work of an appropriate level and can obtain job satisfaction.

Public relations—activities such as positive news releases and supportive TV programmes are needed to create a higher and more acceptable profile for the industry. Initiatives to change opinions must include both young people and the general public. Jeremy Clarkson's bullish promotion of Brunel as the Greatest Briton will be remembered by many. Similar programmes could be justified about George and Robert Stephenson, Telford and the remarkable navvies who tramped the length of the country to build Britain with their bare hands. Are these subjects less interesting than the three one-hour programmes recently broadcast about The Spartans? Perhaps other programmes could feature recent works such as the Second Severn Bridge, or the story of the 1953 east-coast floods, the Thames Barrier and potential sea level rise? Could the ICE help to produce such programmes? Could the ICE also notify the media of 'experts', at Great George Street and in the regional



chool activities, such as this spaghetti tower competition, need to be gender-inclusive



ig. 7. Competitions such as model bridge-building can be brought up to date by the need to drive remotely controlled models across them

associations, who would comment on relevant issues? Although potentially this could lead to conflict, engineers must be prepared to speak about subjects of public concern, even when controversial, and to lead public opinion. Too often this is left to less informed activists or laypersons.

Promotion in schools—there needs to be a sustained commitment to educate young school students about the engineering profession. Lack of information frequently results in the assumption that engineering is boring, and this opinion is often firmly entrenched by the mid-teens. Any promotional campaign needs to be well funded and coordinated. There are currently initiatives that involve individual consultants and contractors, the ICE, the CITB, the Construction Industry Council, colleges, universities and government. Without coordination some schools can receive a confusingly large number of approaches, but others none at all. Can better coordination be achieved at national and regional level?

School activities—these must be interactive, interesting and capable of appealing to a generation brought up on hi-tech computer games. Such activities must also be gender-inclusive, to avoid the unwitting exclusion of girls and a reinforcement of the masculine image. This is not always easy, but is acchievable; some activities run by the authors were enjoyed or enjoyed a lot by 99% of participants (Figs 6 and 7). Badly devised and presented activities reinforce the negative stereotypes. Could the ICE's School Zone website describe activities that have a proven record of success, and a list of contacts who would provide additional advice?

Work experience—one way to reduce 'invisibility' is through work experience; in one survey 93% of students who had undertaken work experience with an engineering company found it useful. [7] In the UK, most young people are required to carry out work experience while still in compulsory education (see Table 5 for some useful contacts). The engineering sector therefore needs to ensure it offers stimulating and accessible placements, positively promoting opportunities for female students. In this way it can raise the profile of the industry and encourage the most talented young people of either sex to consider it as a career option. However, one newly created, specialist engineering school has reported little interest from civil engineering firms.[19] Often the problem is knowing who to contact; large companies could appoint and publicise internally a schools' liaison officer (some already have) so that there is a focal point for enquiries.

Undergraduates—one of the best ways to promote a career to school students is via the recommendation of satisfied undergraduates. With civil engineering this is problematic because, compared to their peers, many students work longer hours and struggle with very full, mathematical courses.[17] A recent report claimed that engineers also crave art and creativity.[20] Nobody is arguing for a reduction in standards but, to increase students' enjoyment, is it time for the ICE to allow more flexibility in the content and delivery of university syllabuses?

Conclusions

Many school students, through lack of knowledge or negative perceptions, dismiss engineering as a career at an early age. Although the suggestions presented above to address this problem are not new, by outlining some of the factors that influence students' career choices it is possible to understand why such measures are necessary.

In the past the need for action has been recognised but, often for economic reasons, either nothing has been done or the response has been low key, fragmented and short term. It is unlikely that purely cosmetic changes and short-term measures will produce a lasting change in young people's perception of civil engineering, or the status to which it aspires.

If applications to civil engineering courses are to be held at acceptable levels and the skills crisis overcome, civil engineering needs to change its culture, smarten its image and undertake a coordinated and sustained programme of interesting, well-designed events for schools.

Table 5. Some useful contacts and schemes involving schools

Activity	Description	Organisation/contact
Engineering Education Scheme	School students working with industry to solve real problems	Royal Academy of Engineering www.engineering-education.org.uk
Headstart	University taster courses in collaboration with industry	Royal Academy of Engineering www.headstartcourses.org.uk
Year In Industry	Relevant gap year employment in industry	Royal Academy of Engineering www.yini.org.uk
Helping people in education and people in business to come together	Work placements for teachers, school students and similar activities	Education-Business Partnerships Scotland: www.ebp.org.uk Other parts of UK: see local phone book or below
Helping people in education and people in business to come together	Work placements for teachers, school students and similar activities	Education Business Link Organisation (eblo) Cambridgeshire: www.cambseblo.org.uk Other regions: see local phone book
ICE School Zone website	Information, games, careers, competitions, projects, events	Institution of Civil Engineers www.ice.org.uk/schoolzone

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