'DANGER! MEN AT WORK:

A STUDY OF THE UNDER-REPRESENTATION OF WOMEN IN THIRD LEVEL ENGINEERING

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DECEMBER 2004

TABLE OF CONTENTS

1.	**BACKGROUND TO THE STUDY**	**1**
1.1	INTRODUCTION	1
1.2	STUDY OBJECTIVES	1
1.3	TERMS OF REFERENCE	2
1.4	METHODOLOGY	2
1.4.1	*Literature Review*	*2*
1.4.2	*Analysis of Labour Market and Education Statistics*	*3*
1.4.3	*Key Informant Interviews*	*3*
1.4.4	*Focus Groups*	*3*
1.4.5	*Survey of Careers Guidance Counsellors*	*3*
1.4.6	*Survey of Secondary School Pupils*	*3*
1.4.7	*Interviews with Women Engineers*	*3*
1.4.8	Identification of Policy Measures/Interventions	3
1.5	SUMMARY OF CONTENTS	4
2.	**STATISTICAL ANALYSIS OF FEMALE REPRESENTATION IN ENGINEERING**	**5**
2.1	ENGINEERING EMPLOYMENT	5
2.2	WOMEN WITH ENGINEERING QUALIFICATIONS	6
2.3	CURRENT FEMALE REPRESENTATION IN ENGINEERING AT TERTIARY LEVEL	7
2.3.1	*Engineering Graduates*	*7*
2.3.2	*Women in Engineering Courses at Irish Universities*	*8*
2.4	FEMALE REPRESENTATION AT SECONDARY LEVEL EDUCATION	8
2.5	CONCLUSIONS	9
3.	**LITERATURE REVIEW**	**10**
3.1	INTRODUCTION	10
3.2	RATIONALE FOR RESEARCH ON THE UNDER-REPRESENTATION OF WOMEN IN ENGINEERING	10
3.2.1	*Shift to a Knowledge Based Society*	*10*
3.2.2	*Added Value of Diversity in engineering*	*11*
3.3	WOMEN'S PARTICIPATION IN HIGHER EDUCATION	11
3.4	FEMALE PARTICIPATION IN SECONDARY LEVEL EDUCATION	13
3.4.1	*The Maths Curriculum*	*13*
3.4.2	*Access to Maths and Science Subjects*	*14*
3.4.3	*Perceived 'Image' of Maths and Sciences*	*15*
3.4.4	*Exam Performance*	*15*
3.4.5	*Textbook Bias*	*15*
3.4.6	*Classroom Experience/Bias*	*15*
3.5	CAREER GUIDANCE AND GUIDANCE COUNSELLOR INFLUENCES	16
3.6	SOCIAL ISSUES RELATING TO WOMEN IN ENGINEERING	17
3.6.1	*Parental Influences*	*17*
3.6.2	*Image is Everything*	*17*
3.6.3	*Lack of Experience with Engineering Toys*	*17*
3.6.4	*Loss of Self-Esteem as a Teenage Girl*	*18*
3.6.5	*Lack of Role Models*	*18*
3.7	CONCLUSIONS	19

4. SURVEY OF GUIDANCE COUNSELLORS IN POST-PRIMARY SCHOOLS 20

4.1 SURVEY OBJECTIVES 20
4.2 SURVEY METHODOLOGY 20
4.3 PROFILE OF RESPONDENTS 21
4.3.1 Gender of Respondents 21
4.3.2 Length of Service in Current School 21
4.3.3 Subjects Taught 22
4.3.4 Working Time Arrangements 22
4.4 PROFILE OF SCHOOLS 22
4.4.1 School Location 22
4.4.2 Type of School 23
4.5 GUIDANCE COUNSELLORS EXPERIENCE OF ENGINEERING 23
4.5.1 Introducing Pupils to Engineering 23
4.5.2 Access to Engineering Careers Information 24
4.6 PUPILS' CHOICE OF ENGINEERING AT THIRD-LEVEL 26
4.6.1 Reasons for Studying Engineering at Third-Level 26
4.6.2 Negative Factors that Discourage the Study of Engineering 26
4.7 CAREER INFLUENCES FOR CHOOSING ENGINEERING 27
4.8 PREFERRED PATH TO STUDY ENGINEERING AT THIRD-LEVEL 28
4.8.1 Common-Entry Engineering 29
4.8.2 Direct-Access Engineering 30
4.9 CONTACT WITH SCHOOLS BY ENGINEERING STAKEHOLDERS 30
4.9.1 Contact with Engineering Firms 30
4.9.2 Contact with Third-Level Institutes 31
4.9.3 Contact with Engineering Initiatives 31
4.10 USEFULNESS OF ENGINEERING MATERIALS PROMOTED BY ENGINEERING STAKEHOLDERS 32
4.10.1 Usefulness of Material/Events from Engineering Firms 33
4.10.2 Usefulness of Material from Third-Level Institutes 33
4.10.3 Usefulness of Materials from IEI and STEPS 34
4.10.4 Usefulness of STEPS/IEI Seminar 35
4.11 FURTHER ACTIONS TO PROMOTE ENGINEERING FOR FEMALE PUPILS 35
4.12 Promotion Efforts aimed at Female Pupils 35
4.13 FUTURE PROMOTIONAL OPPORTUNITIES 37
4.13.1 Parental Role 37
4.13.2 Role of Schools 38
4.13.3 Role of Higher Education Institutions and the Institution of Engineers of Ireland 39
4.13.4 Role of the State and Department of Education 41
4.14 CONCLUSIONS 42

5. SURVEY OF SECONDARY SCHOOL PUPILS 44

5. 1 INTRODUCTION 44
5.1.1 Background to the Survey 44
5.1.2 Survey Objectives 44
5.1.3 Survey Methodology 45
5.2 PROFILE OF SCHOOLS SURVEYED 46
5.2.1 Location of School 46
5.2.2 Gender Composition of School 47
5.2.3 Type of School 47
5.3 PROFILE OF PUPILS IN SCHOOLS SURVEYED 47
5.3.1 Gender of Respondents 47
5.3.2 Junior Certificate Subject Taken 48
5.3.3 Leaving Certificate Subjects Taken 49
5.3.4 Subject Pre-requisite for studying Engineering at Third-Level 50

5.4	ENGINEERING AS A CAREER CHOICE	50
5.4.1	*CAO Applications*	*50*
5.4.2	*Engineering as a CAO option*	*51*
5.4.3	*Reasons for Not Choosing Engineering - Male pupils*	*51*
5.4.4	*Reasons for Not Choosing Engineering - Female pupils*	*52*
5.4.5	*Applied for Engineering*	*53*
5.4.6	*Reasons for Accepting Engineering if Offered by CAO- Male Pupils*	*54*
5.4.7	*Reasons for Accepting Engineering if Offered by CAO- Female Pupils:*	*54*
5.4.8	*Degree Preferences for Engineering*	*54*
5.4.9	*Diploma Course Preferences*	*55*
5.5	KEY INFLUENCES TO STUDY ENGINEERING	55
5.5.1	*Family Members who Studied Engineering*	*55*
5.5.2	*Key Career Influences*	*55*
5.5.3	*Encouraged to Study Engineering*	*56*
5.5.4	*Discouraged from Studying Engineering*	*57*
5.6	BELIEFS ABOUT ENGINEERING	57
5.6.1	*Image of Engineering Courses/Study*	*57*
5.6.2	*Gender Issues within Engineering*	*59*
5.7	PERCEPTIONS OF THE SKILLS/TRAITS OF AN ENGINEER	62
5.7.1	*Personal Traits of Engineers*	*62*
5.7.2	*Skills of an Engineer*	*62*
5.8	PERCEPTIONS OF GENDER ROLES IN DIFFERENT PROFESSIONS	63
5.9	EXPOSURE TO ENGINEERING	64
5.9.1	*Engineering Task Experience*	*64*
5.9.2	*Access to Role Model Engineers*	*65*
5.10	ACCESS TO ENGINEERING INFORMATION	66
5.10.1	*Engineering Events*	*66*
5.10.2	*Engineering Promotional Materials*	*67*
5.11	VIEWS ON ENGINEERING	68
5.11.1	*Comments from Male Pupils about Engineering:*	*68*
5.11.2	*Comments from Female pupils on Engineering*	*69*
6.	**FOCUS GROUPS**	**71**
6.1	INTRODUCTION	71
6.2	FOCUS GROUP METHODOLOGY	71
6.3	CAREER ASPIRATIONS	71
6.4	COURSE/POINTS REQUIREMENTS	72
6.5	CHOOSING ENGINEERING AT LEAVING CERTIFICATE	73
6.5.1	*Why so Few Girls in Engineering Classes?*	*73*
6.6	CHOICE OF ENGINEERING AT THIRD-LEVEL	74
6.7	PERCEPTIONS OF ENGINEERING AS A PROFESSION	75
6.7.1	*What do Engineers Do?*	*75*
6.7.2	*What do Pupils Associate with 'Engineering'?*	*75*
6.7.3	*Profile of an Engineer*	*75*
6.7.4	*Perception of the Engineering Environment*	*76*
6.8	SOCIETAL ROLES OF MEN AND WOMEN	76
6.8.1	*Gender Specificity of Jobs*	*76*
6.8.2	*Obstacles for Women Studying Engineering*	*77*
6.8.3	*Image of a Woman Engineer*	*77*
6.9	INFLUENCES ON CAREER DECISIONS	78
6.10	VIEWS ON ENGINEERING PROMOTIONAL MATERIAL	78
6.11	CONCLUSIONS	79

7. CASE STUDIES OF FEMALE ENGINEERS 81

7.1 INTRODUCTION 81
7.2 CASE STUDY METHODOLOGY 81
7.3 CASE STUDY OF THE CONSULTANT ENGINEER, AMY 81
7.3.1 Family Background and Education 81
7.3.2 Role-Models and Influences 82
7.3.3 Career Development and Promotion 82
7.3.5 Why Amy is successful in her career 82
7.3.6 Culture and Image of Engineering in the Private Sector 82
7.3.7 Women in Engineering 83
7.4 CASE STUDY OF THE FORMER ENGINEER, BARBARA 83
7.4.1 Family Background and Education 83
7.4.2 Role-Models and Influences 83
7.4.3 Culture of Engineering at University 84
7.4.4 Why Barbara Never Worked as an Engineer 84
7.4.5 Debunk the Myth: What further actions can be taken? 84
7.5 CASE STUDY OF THE ACADEMIC ENGINEER, CHRISTINE 85
7.5.1 Family Background and Education 85
7.5.3 Career Development and Promotion; 85
7.5.4 Work-Life Balance 85
7.5.5 Why Christine is Successful in her Career 85
7.5.6 Culture and Image of Engineering in Academia 86
7.5.7 Debunk the Myth What further actions can be taken? 86
7.6 CASE STUDY OF THE SITE ENGINEER, DEIRDRE 86
7.6.1 Family Background and Education 86
7.6.2 Role-Models and Influences 87
7.6.3 Career Development and Promotion; Work-Life Balance 87
7.6.4 Culture and Image of Engineering at University and the Public Sector 87
7.6.5 Debunk the Myth What further actions can be done? 88
7.7 CONCLUSIONS 88
7.7.1 Family Background and Education 88
7.7.2 Role-Models and Influences 88
7.7.3 Career Development, Promotion and Work-Life Balance 88
7.7.4 The University Culture and Image of Engineering 89
7.7.5 Debunk the Myth: Further Actions 89
7.8 CONCLUSIONS 90

8. BEST PRACTICE MODELS 91

8.1 INTRODUCTION 91
8.2 APPROACH TO REVIEW OF MEASURES 91
8.3 PRIMARY SCHOOL INTERVENTIONS 92
8.3.1 Science Curriculum at Primary School 92
8.4 LACK OF EXPOSURE TO ENGINEERING 93
8.5 THE IMAGE OF ENGINEERING 93
8.6 WOMEN IN ENGINEERING ADVISOR AT THIRD-LEVEL 93
8.7 ROLE MODELS, MENTORING AND NETWORKING FOR WOMEN IN ENGINEERING 94
8.7.1 Need for Role Models 94
8.7.2 Role Models Initiative in United Kingdom & Europe 94
8.7.3 Mentor Models 95
8.7.4 Mentoring in Ireland 95
8.7.5 Networking Models 96
8.8 POLICY AND BEST PRACTICES AT EUROPEAN LEVEL 96
8.9 HOLISTIC APPROACHES 96
8.9.1 JIVE (Joint Intervention) 97

8.9.2 United Kingdom National Resource Centre (UKRC) for Women in SET 97

9. CONCLUSIONS AND POLICY RECOMMENDATIONS

99

9.1 CONCLUSIONS 99
9.1.1 Statistical Review 99
9.1.2 Literature Review 99
9.1.3 Role of Guidance Counsellors 100
9.1.4 Views of Leaving Certificate Pupils 101
9.1.5 Focus Group Discussions among Secondary Pupils 102
9.1.6 Career Trajectories of Female Engineering Graduates 103
9.2 POLICY RECOMMENDATIONS 104
9.2.1 Establishment of a Task Force on Women into Engineering 104
9.2.2 National Engineering Centre 104
9.2.3 National Media Campaign 105
9.2.4 Primary Level Intervention 105
9.2.5 Secondary School Level 105
9.2.6 Support to Secondary Schools 106
9.2.7 Tertiary Level Education 106
9.2.8 Diversity and Awareness 107
9.2.9 Public Recognition and High Visibility for Women 107

BIBLIOGRAPHY 108

APPENDIX A QUESTIONNAIRE TO GUIDANCE COUNSELLORS A.1
APPENDIX B LETTER TO GUIDANCE COUNSELLORS B.1
APPENDIX C COMPANIES IN TOUCH WITH SCHOOLS C.1
APPENDIX D HIGH TECH COMPANIES/SPONSORS OF STEPS D.1
APPENDIX E LETTER TO TEACHERS E.1
APPENDIX F LETTER TO STUDENTS F.1
APPENDIX G QUESTIONNAIRE TO LEAVING CERTIFICATE STUDENTS G.1

1. Background to the Study

1.1 Introduction

This study was undertaken on behalf of the Gender Equality Unit, Department of Education and Science, in January 2002, to identify the factors militating against girls selecting/applying for/enrolling in courses of study in engineering at third level institutions in Ireland.

Underlying this research is the skewed and highly gendered pattern of employment in the engineering professions in Ireland, as in other countries worldwide. In 2002 women constituted 41 per cent of the Irish labour force; 21 per cent of workers engaged in scientific and technical occupations but only 12 per cent of engineering professionals[1] (Central Statistics Office 2003).

Despite forming 52 per cent of all degree holders in 2002 in Ireland, women accounted for 11 per cent of the 35,628 people with degrees in engineering/architecture in 2002 and 7 per cent of the 22,750 persons with a non-degree engineering/architectural qualification.

At third level, there are currently more female than male students – 58 per cent versus 42 per cent. In 2002/3 academic year the ratio of female to male engineering students was 19 per cent overall. However the ratio varied according to third level institution from 15 per cent to 27 per cent.

Yet research by Drew and Murphy (2000) showed that girls are at least as well qualified as boys in meeting the CAO requirements for studies in engineering, suggesting that the answers lie outside of academic performance in areas such as:

- Gender stereotyping of the engineering professions
- Negative/macho images of engineers
- Deficit in encouragement/support/information to pursue engineering studies
- Lack of female role models
- Nature of the curriculum and teaching methods.

1.2 Study Objectives

The objectives of this research were to:

- identify the obstacles to girls applying for, and enrolling in, engineering courses at third level in Ireland;
- examine the determinants that attract female students into engineering courses;

[1] Engineering professionals comprise: civil and mining, mechanical, electrical and electronic, chemical, production, planning and quality control, design and development and other engineers and technologists.

- recommend practical measures that would lead to a more equitable gender balance on such courses.

1.3 Terms of Reference

The terms of reference for the project that were agreed with the Department of Education and Science and Research Steering Group were to:

- Carry out interviews with key informants in the secondary and tertiary education sectors;
- Undertake a literature review of national and international data, including www sites, to identify:
    - obstacles to girls entering engineering courses;
    - career paths among women engineering graduates and
    - best practice models;
- Analyse existing data sources on engineering professionals, students and applicants to engineers courses of study at third level;
- Conduct a survey of Careers Guidance Teachers in Irish secondary schools;
- Carry out a national survey of secondary school female and male pupils to ascertain their knowledge and perceptions of, and interest in, studying engineering;
- Organise Focus Group discussions with potential school leavers;
- Conduct interviews with women engineers with diverse career paths.

1.4 Methodology

In order to meet the terms of reference outlined above the following methodologies were applied in the current study.

1.4.1 Literature Review

The literature review focused on analysing available sources of information on:

- Factors contributing to women's under-representation in the engineering professions and courses of study at third level;
- Measures to address women's under-representation in engineering, particularly at third level.

1.4.2 Analysis of Labour Market and Education Statistics

This analysis involved reviewing available statistics on trends in the pool of women with engineering qualifications and who are studying engineering based on international and Irish data sources.

1.4.3 Key Informant Interviews

Interviews were conducted with key informants in relevant educational and governmental organisations in order to obtain their views on how best to address the under-representation of women in engineering occupations and third level degree courses in Ireland.

1.4.4 Focus Groups

Three focus groups were conducted in all girls/all boys/co-ed schools to elicit the views and perceptions of secondary level pupils towards engineering as a potential course of study.

1.4.5 Survey of Careers Guidance Counsellors

A survey of guidance counsellors was undertaken to establish:

- what guidance counsellors knew about engineering;
- why pupils choose engineering or otherwise;
- the system of entry to engineering courses preferred by pupils and why;
- the usefulness of information on engineering;
- who the most influential person are for pupils when choosing their careers;
- what could be done to encourage female students into engineering.

1.4.6 Survey of Secondary School Pupils

A survey of final year Leaving Certificate pupils attending post-primary schools was undertaken to ascertain:

- subject choice in Leaving Certificate examination;
- knowledge of subjects that are a pre-requisite to studying engineering;
- if they have applied to engineering courses through the CAO system and why;
- understanding of the role of an engineer;
- perceptions of the personal characteristics and skills of an engineer;
- the technical competence/experiences of pupils;
- who the key influencers are in career decisions;
- usefulness or otherwise of information on engineering.

1.4.7 Interviews with Women Engineers

The study sought to obtain information on the personal career histories of women who had embarked upon engineering studies, to establish why they had chosen that field and their experience during and after their studies. Four interviews were conducted to trace the careers of contrasting female engineering graduates.

1.4.8 Identification of Policy Measures/Interventions

This stage of the study involved reviewing measures that have been used to date to address the under-representation of women in engineering in Ireland or abroad.

1.5 Summary of Contents

Chapter 2 sets out the analysis of limited secondary data on women's representation in the engineering professional and third level engineering courses in Ireland. This is followed by a review of literature that examines the reasons for women's under-representation, particularly in tertiary education.

In Chapter 4 presents the results of the survey of guidance counsellors in Irish schools. This is followed by the national survey of Leaving Certificate pupils in Irish secondary schools in Chapter 5.

Following these mainly quantitative survey chapters, Chapter 6 reports the findings of the focus groups with secondary pupils while Chapter 7 contains the career histories of women engineers based on personal interviews.

Chapter 8 outlines the range of actions/interventions undertaken to address the under-representation of women in engineering. Chapter 9 draws upon the earlier chapters and presents the conclusions and recommendations for policy intervention.

2. Statistical Analysis of Female Representation in Engineering

This chapter examines the national statistics for women's representation among: engineering professionals/technicians; holders of third level engineering qualifications; recent engineering graduates, and current third level students, against a backdrop (where available) of international comparisons. It concludes with a section on the potential pool of engineering students from secondary level pupils who hold the necessary entrance qualifications to study engineering at university/IT level.

2.1 Engineering Employment

The national source of data on occupations is from the Census of Population. For ease of interpretation this section utilises the categories specified by the Central Statistics Office: Technical relating to engineering occupations including engineering professionals and engineering technicians (Table 2.1).

Table 2.1 Women's Representation in Engineering Occupations 1991-2002

	Percentage of Women		
Specific Occupation	**1991**	**1996**	**2002**
Civil and Mining Engineers	3 %	6 %	9%
Mechanical Engineers	2 %	4 %	6%
Electrical/ronic Engineers	5 %	5 %	8%
Chemical, Production, QC Engineers	19 %	21 %	26%
Design & Development Engineers	11 %	10 %	14%
Other Engineers/Technologists	6 %	10 %	12%
Engineering Technicians	4 %	12 %	7%
Electrical/Electronic Technicians	7 %	10 %	6%
Architectural/Civil Engineer Technicians	13 %	15 %	14%
Draughtspersons	9 %	10 %	12%
Building Inspectors & Surveyors	4 %	5 %	11%
Marine, Insurance/other Surveyors	4 %	9 %	10%
Total	**8%**	**9%**	**11%**

Source: Census of Population 1996, Vol. 7, Occupations, Table 8 (1998); Census of Population 2002, Occupations, Volume 6, Table 8 (2003).

Table 2.1 demonstrates the consistently low level of women in engineering occupations while indicating a slight upward trend since 1991. In the first five years of the 1990s women's representation increased by only one percentage point. In the next six years from 1996-2002 it increased by 2 percentage points. Among engineering professionals there was a threefold increase in

the representation of women as civil/mining and mechanical engineers from 1991-2002, albeit from a very low base. The strongest sectors of engineering for women are: chemical, production and quality control in which women comprise 26 per cent, followed by design/development engineering (14% of the total) and other engineers/technologists (12% of the total).

Table 2.2 shows that the number of women in engineering professional occupations increased significantly between 1991-2002, particularly as electrical/electronic engineers (from 34 in 1991 to 309 in 2002) and 'other' engineers (from 324 in 1991 to 671 in 2002). However, the proportion of women in such occupations remains significantly lower than that for men since male employment in engineering rose from 14,600 in 1991 to 30,816 in 2002 compared with an increase among women engineers from 1,248 in 1991 to 3,837 in 2002.

Table 2.2 Wo/Men's Representation in Engineering Occupations by Gender in 1991-2002 (% in brackets)

Specific Occupation	Women 1991	Men 1991	Women 2002	Men 2002
PROFESSIONAL				
Civil and Mining Engineers	105 *(3%)*	3006 *(97%)*	467 (9%)	4599 (91%)
Mechanical Engineers	28 *(2%)*	1207 *(98%)*	105 (6%)	1783 (94%)
Electrical/ronic Engineers	34 *(5%)*	634 *(95%)*	309 (8%)	3649 (92%)
Chemical, Production, QC Engineers	427 *(19%)*	1810 *(81%)*	817 (26%)	2340 (74%)
Design & Development Engineers	58 *(11%)*	475 *(89%)*	224 (14%)	1345 (86%)
Other Engineers/Technologists	32 *(6%)*	469 *(94%)*	671 (12%)	4956 (88%)
TECHNICAL				
Engineering Technicians	33 *(4%)*	751 *(96%)*	159 (7%)	1985 (93%)
Electrical/electronic Technicians	154 *(7%)*	2019 *(93%)*	242 (6%)	3553 (94%)
Architectural, Civil Eng Technicians	109 *(13%)*	715 *(87%)*	398 (14%)	2395 (86%)
Draughtspersons	221 *(9%)*	2282 *(91%)*	265 (12%)	1945 (88%)
Building inspectors & Surveyors	43 *(4%)*	1140 *(96%)*	170 (7%)	2173 (93%)
Marine, Insurance/other Surveyors	4 *(4%)*	92 *(96%)*	10 (10%)	93 (90%)
TOTAL	**1,248 (8%)**	**14,600 (82%)**	**3,837 (11%)**	**30,816 (89%)**

Source: Census of Population 1996, Vol. 7, Occupations, Table 8 (1998); Census of Population 2002, Occupations, Volume 6, Table 8 (2003).

2.2 Women with Engineering Qualifications

Table 2.3 shows the number and percentage of women among those who hold engineering qualifications and how these have changed since 1986. In 1986 only 4 per cent of individuals with an engineering qualification were female compared with 9 per cent in 2002. Comparable statistics for engineering graduates in other states are difficult to locate/compare. However gender specific data for US engineering degree holders show that there has been an increase in female representation from less than 1 per cent in 1966 (146 women out of 35,826 engineering graduates) to 20 per cent in 2001

(11,914 women out of 59,258 engineering graduates). The US data suggest that the current level of female engineering graduates in Ireland is *comparable to that prevailing in the US in 1979.*

Table 2.3 Number of Persons with an Engineering Qualification in 1986 to 2002

	1986			1996			2002		
	No. Men	No. Women	% Women	No. Men	No. Women	% Women	No. Men	No. Women	% Women
Engineering	27,349	1,092	4%	55,409	3,932	7%	56,783	5,817	9%

Source: Census of Population, Education and Qualifications, Vol.8, Table 19, CSO (1998), Census of Population, Education and Qualifications, Vol.7, Table 20, CSO (2004).

Of the 56,783 men with engineering qualifications in 2002 56 per cent had obtained a degree or higher qualification. This compared with 69 per cent of the 5,817 women who had degrees, or a higher qualification, in engineering in 2002.

In 2002 93 per cent of women with an engineering qualification were aged under 45 years. The comparable figure for men was 76 per cent. This younger age profile of women engineers suggests that they will comprise an increasing number and percentage of future engineering students/graduates and professionals in Ireland.

Comparative data on engineering graduates across 21 European states, including Ireland, show considerable variation in the proportions of women who studied engineering. By 1995 (the latest figures available) only 2.4 per cent of women with degrees had studied engineering. In the same year the figure for male Irish graduates who had studied engineering was 17.3 per cent, almost one in five. Among these European states the percentage of male graduates with a degree in engineering ranged from 11 per cent in Iceland to 51 per cent in the Russian Federation. The level of female engineering graduates among degree holders was higher for women in Central/Eastern European states: 13 per cent in Bulgaria and the Russian Federation, Serbia and Montenegro and 20 per cent in Slovakia. Only Cyprus (1%) and Austria (2%) had proportionately fewer women graduates than Ireland who had studied engineering.

2.3 Current Female Representation in Engineering at Tertiary Level

2.3.1 Engineering Graduates

Data from the Higher Education Authority show that female students accounted for 58 per cent of *all* full-time undergraduate enrolments in the academic year 2002/3. In 2002 women were awarded 22 per cent of primary degrees in engineering (excluding IT studies). This level contrasts sharply with their high level of representation in social science (88%), education (83%), arts (67%), law (64%), medicine (61%), science (60%) and business/economic and social studies (59%). In each of these fields, there are a majority of female students.

Table 2.4 Undergraduate Engineering Graduates in 2002 by Universities

University	No. Male	No. Female	Total	% Female Graduates
Dublin City University	84	16	**100**	**16%**
University College Dublin	173	64	**237**	**27%**
University College Cork	114	32	**146**	**22%**
National UGI	161	39	**200**	**20%**
TCD	199	55	**254**	**22%**
	731	**206**	**937**	**22%**

Source: HEA Annual Report, 2002/03, Table 55. Available online at http://www.hea.ie/

Having looked at the proportion of women among engineering graduates, this section examines the gender profile of undergraduate and postgraduate students who are currently pursuing engineering at Irish Universities and Institutes of Technology.

2.3.2 Women in Engineering Courses at Irish Universities

The proportion of women studying engineering at tertiary level in 2001-2 (the most recent data available) was 18 per cent. At degree (undergraduate and masters) level women comprised nearly one-quarter (23%) of undergraduate enrolments, compared with 12 per cent of total enrolments at certificate/diploma level. At doctoral studies level female students accounted for 22 percent of the total, suggesting a high level of retention within the university sector among female engineering graduates.

Table 2.5 All Tertiary Level Students in Engineering, Manufacturing and Construction 2001-2

Tertiary Level	No. Male	No. Female	Total	% Female Students
Certificate/Diploma	7,741	1,036	**8,777**	**12%**
Undergraduate/Masters	8,333	2,451	**10,784**	**23%**
Doctoral Students	320	90	**410**	**22%**
Total	**16,394**	**3,577**	**19,971**	**18%**

Source: Dept. of Education and Science (Unpublished) 2005

2.4 Female Representation at Secondary Level Education

The participation of girls in secondary level education has been rising steadily since the 1960s (Hannan et al. 1983). Since the most common subject requirement for engineering is a 'C' in higher-level mathematics it is the cohort/pool of boys/girls taking Higher Level papers in mathematics and achieving a C grade or better that ultimately determines their eligibility to enter an engineering degree programme (though pupils may enter Institutes of Technology with lower level qualifications to pursue certificates/diplomas, and ultimately degrees) at third level.

Data on Leaving Certificate participation show that 5,130 boys and 4,300 girls sat the higher level mathematics papers. Hence female pupils accounted for 46 per cent of those taking higher level mathematics at Leaving Certificate level. Of the boys 3,761 (73%) achieved a grade of C or better. A

total of 3,304 girls achieved the equivalent grade, 77 per cent of those who sat the higher level paper. These data show that female school leavers comprise 47 per cent of the potential pool of school leavers holding a grade C or better in High Level mathematics.

Girls accounted for 57 per cent of those taking chemistry at higher level and 72 per cent of those taking biology. However only 1,769 girls took physics at higher level, or 30 per cent of the total, compared with 4,218 boys (70%). If grades of A and B at higher level are examined girls out-perform their male counterparts. In higher level maths, 43 per cent of girls but only 40 per cent of boys achieved a grade of A/B. While fewer girls took physics at the higher level, 47 per cent of them achieved grades of A/B compared with 36 per cent of boys. The performance of boys/girls in these subjects further illustrates the common pattern at Junior Certificate and Leaving Certificate levels in which, with minor subject exceptions, girls achieve higher grades than their male counterparts.

Based on Leaving Certificate performance to date there are no academic explanations for the concentration of girls in science (particularly the life sciences) but not in engineering at tertiary level.

2.5 Conclusions

The analysis of the available statistics provides important insights into the under-representation of women in the engineering profession in Ireland. Comparative US data for employment of engineers suggest that Ireland is JUST reaching the gender ratio that pertained in the US in 1979.

Working back through statistics for female engineering graduates and potential female applicants to engineering it is evident from Leaving Certificate data that while fewer girls (46% of the total) are taking higher level maths courses at leaving certificate level, proportionately more girls are achieving the grade (C or better) required for enrollment for courses in engineering at tertiary level.

The results indicate that strategies aimed at raising the number of women in engineering occupations, hence holding engineering qualifications, need to focus on encouraging more girls to study engineering at third level.

Chapter 3 concentrates on identifying the factors that discourage the potential entry of girls into engineering courses at third level in order to establish how these factors might be addressed.

3. Literature Review

3.1 Introduction

Existing research on the under-representation in engineering occupations/course has tended to link engineering with science and technology using the acronym SET (Science, Engineering and Technology). While many of these studies are useful in grasping the nature and scope of women's participation into engineering they nevertheless distort the patterns and explanations for women's participation in engineering. International and Irish statistics show that women's participation in undergraduate science courses has reached a 50:50 male: female participation. Engineering is not yet at this equal level – as Irish data indicate (Chapter 2). Hence engineering needs to be addressed as a separate entity. Despite the evident deficit of women in engineering professions/courses, research studies that focus *exclusively* on the factors that hinder female secondary schools from choosing engineering are scarce.

By grouping engineering with other disciplines such as science and technology, many researchers have failed to take account of the unique nature of engineering both as a profession and as a discipline in tertiary level education. Engineering is *not a science* and has had a very different developmental history to science (Yurtseven 2002). Engineering in Ireland is made up of many different disciplines (Byrne 2002), each quite different from the other namely: Chemical and Process; Civil; Electrical; Electronic; Mechanical; Aeronautical; Biomedical; Building Services; Computer and Software; Food and Agricultural; Manufacturing and Industrial; Materials; Mechatronics/Electromechanical; and Structural.

Chapter 2 shows that while there are variations in the levels of female representation in these engineering sub-disciplines the consistent feature is low levels of female participation.

3.2 Rationale for Research on the Under-representation of Women in Engineering

The main reasons have been provided to justify research leading to an increase in the participation of women in engineering: shift towards a knowledge intensive society and added value of diversity within the profession. These are outlined below.

3.2.1 Shift to a Knowledge Based Society

Knowledge is now recognised as the driver of productivity and economic growth, leading to a new focus on the role of information, technology and learning in economic performance. A knowledge-based economy requires a highly skilled workforce and a society which readily incorporates new technologies. This new society is directly based on the production, distribution and the use of knowledge and information (OECD 1996).

Science and Engineering Systems [Educational Institutes] are recognised as carrying out key functions in the knowledge-based economy, including the knowledge production, transmission and transfer. The engineering system needs to reconcile its traditional function of producing new

knowledge through basic research and educate new generations of engineers with a new role of collaborating with industry. The problem-solving function is being given more emphasis on the knowledge-based economy indicating that the role of an engineer is becoming increasingly more vital for a sustainable economy (OECD 1996).

Europe aims to become *"the most competitive and dynamic knowledge-based economy in the world by 2010"* [Address by Mr. Busquin, Member of the European Commission at the European Business Summit, Brussels, 2002]. Ireland is committed to this objective. The report, "The Demand and Supply of Engineers and Engineering Technicians" predicts a decrease in graduate numbers in engineering and in first preferences to study engineering indicating that the supply of engineering graduates has not kept pace with the supply of graduates in general. The authors also acknowledge the need to produce more engineering graduates to enhance a knowledge-based economy yet there has been a decline of interest in engineering (McIver 2003). As women in engineering have shown to be a highly skilled talent pool, tapping into these resources will help to meet the future engineering and economic demands.

3.2.2 Added Value of Diversity in the Engineering Profession

With the importance of engineering within the knowledge-based economy, women are vital components in bringing added value to the engineering environment, be at third-level or the engineering profession. Research shows that by having a diverse workforce, this leads to increased organisational performance. A diverse workforce offers increased innovation, added value and different perspectives, enhanced team effectiveness with an inclusive management style and also brings a healthier emphasis on work-life balance issues (Emerson 2004).

The economic value of women's leadership was highlighted in a recent study by Catalyst Study, Fortune 500, which states that:

> *"the group of companies with the highest representation of women in their top management teams experienced better financial performance than the group of companies with the lowest women's representation. These findings hold for Return on Equity which is 35.1 per cent higher, and Total Return to Shareholders, 34 cent higher"*. (Catalyst 2004)

Greenfield (Peters et al. 2002) cites evidence about the link between share prices and being an 'employer of choice'.

This remainder of this chapter examines national and international literature to ascertain the key factors that contribute to the continuing under-representation of women in engineering particularly at third level which determines the pool of women and men who enter engineering as professionals and technicians.

3.3 Women's Participation in Higher Education

Much research has concentrated on female engineering students who have already entered third level institutions, to discover what factors may have dis/encourage the study of engineering and how they

made their career decisions (Jawitz et al. 1998). There are limitations with this *survey approach*. The target population are female students who have already chosen engineering. There is no information sought from students who may have considered engineering at third-level but changed their mind and taken alternative courses. The target population is also small due to the poor female to male ratio on most engineering courses.

One trend in research examines factors that encourage female students to stay in engineering or science once they are studying at third-level. Positive images of scientists and engineers, support of women's equality, and positive classroom experiences are positively related to retention (Wyer 2003). Sax (1994) found that creating a positive learning environment through cooperative group projects and inclusive (non-sexist, racially diverse) language and textbooks, female retention can be enhanced in engineering.

Other research has investigated the educational climate/culture for women studying in predominantly male engineering courses, with a view to suggesting strategies to combat any difficulties female students may encounter (Davis et al. 1996, Brainhard et al. 1999). This 'chilly' climate includes factors such as a predominantly male culture and classroom experience for both female and male students. Problems can occur in the lecture halls or laboratories where women have been found to feel isolated and can suffer remarks or jokes about being female (Sullivan et al. 2003) and/or are reluctant to ask questions in class for fear of being ridiculed by the (male) majority of students (Brainhard et al. 1999).

Researchers have explored the issue of self-efficacy, defined as the self-perception of a student's ability to learn engineering against the students actual ability to learn in engineering (Colbeck et al. 2001). For example, if a female engineering student has low self-efficacy in maths, this indicates that her self-perception of her ability is lower than her actual ability and performance in maths.

Measures to increase female students' self-efficacy within engineering include collaborative learning practices (Cabrera 2002, Colbeck et al. 2001, Crump 2004, Armstrong 2003). These practices involve changing classroom experience from the current environment of conventional lectures/labs to a more problem-solving, enhanced communication skills, offering leadership qualities and involving frequent interaction with teaching assistants. Drew found evidence of gendered learning preferences with Irish female students preferring small tutorial classes and continuous assessment (Drew et al. 2003). An important shift from the current engineering education is to allow 'critical thinking' (Cabrera et al. 2001, Garcia-Barbosa et al. 1998, Riley 2003) instead of an over-emphasis on teaching advancements in technology (Beder 1989).

There has been little international research to address the factors that influence female pupils who are still attending secondary level including their reasons for choosing or not choosing engineering courses. One US report looked at secondary school female 'high school' students. From this, Blaisdell noted that the academic achievement of a pupil is not sufficient in predicting whether a girl will choose engineering or not (Blaisdell 1998) She suggested other factors such as lack of role-models, socialisation and prior experience as being reasons for women's lack of entry into engineering. A New Zealand study of secondary school pupils found that female students had a low self-efficacy (self-perception) in their mathematical ability (Austin 1995) and scientific ability and suggested that primary schools should be targeted to promote maths and science for female pupils.

3.4 Female Participation in Secondary Level Education

The decision to apply to study engineering at third-level appears to be linked to subject choice at post-primary level. This is partly due to the formal requirements whereby students admitted to any engineering degree course accredited by the Institution of Engineering of Ireland must have a 'C' in higher-level maths. Some colleges also have further subject requirements (McIver 2003). Female students recognise that their performance in maths had a positive influence on their decision to study engineering in University (Cannon et al. 2000, Goodman et al. 2002)

The following section investigates the curriculum and perception of maths and science subjects.

3.4.1 The Maths Curriculum

The maths curriculum have been marked as a negative factor in discouraging female students from considering engineering in the US (Congressional Commission on the Advancement of Women & Minorities in Science 2000), UK (Roberts 2001), and Australia (Willis 1996) where the maths curriculum based studies have examined the format and manner in which students are learning maths. The general consensus is that the maths curriculum needs to be more interactive; and have more applied examples that both male and female pupils can relate to and understand why they are learning the subject. Female pupils like to understand how a subject relates to their surroundings environment.

A benchmark study of science, technology and maths at secondary level, undertaken by the Irish Council for Science, Technology and Innovation (ICSTI) and the National Council for Curriculum and Assessment (NCCA), compared the provision and practice of Science, Technology and Maths (STM) education in the Irish school system and other successful knowledge-based societies (Finland, Scotland, Malaysia and New Zealand). This study found that all societies have moved, or are moving, away from the 'chalk and talk' blackboard culture to more experimental methods with an emphasis on developing problem-solving skills and 'learning by doing' (ICSTI 1999). This problem-solving environment allows students to relate more meaningfully and interactively with the knowledge-based society.

3.4.2 Access to Maths and Science Subjects

Failure to choose the 'right' subjects in school can effectively close the door to engineering careers. Only marginally fewer female pupils are studying Higher Level maths in their Leaving Certificate examinations in Ireland. One in five all-boys schools teach engineering for the Leaving Certificate while no all-girls schools offer engineering as a Leaving Certificate subject. Engineering is not a pre-requisite to study engineering at third level but engineering students at third-level mentioned that it helped them prepare for engineering (McIver 2003). Even with the 'right' subjects being offered in all schools, there may be problems in accessing them because of timetabling constraints whereby some science subjects are timetabled against other perceived less-'difficult' subjects (Smyth et al. 2002, Task Force on the Physical Sciences 2002).

The practice of a 'tiered entry' education system in Ireland comprising Foundation, Ordinary and Higher Levels in the examination process may persuade less confident students (usually girls) to choose the intermediate tier (ordinary level) if they are anxious about failure or did not perform well (Elwood et al. 2003). Entry to the Ordinary Level tier effectively prevents students from taking

subjects to a more advanced level since schools often require grades from the higher tier to advance at that level.

Elwood, in her study of gender and achievement noted that the students who are in the minority in a class, or who take subjects that are 'less traditional for their gender'; often perform better than the majority. An example of this is physics where girls outperform boys in the proportion of top grades but only comprise 15 per cent of those taking the subject (Elwood et al. 2003). Data in Chapter 2 reinforces this finding with respect to physics.

The problem of low levels of self-confidence in female pupils' maths and science abilities has been noted in international literature. Studies from New Zealand have shown that secondary school girls have lower self-confidence in their maths and science ability than male pupils (Austin 1995). A study in Canada showed that boys had a greater interest and perceived ability in science than girls and expressed a belief that they are good at maths while girls believed they are good at language(s), arts and English (Cannon et al. 2002). Comments from Leaving Certificate female pupils from this research indicate that they also better at other subjects such as '*art and history'* or even prefer *'science, over engineering'*.

3.4.3 Perceived 'Image' of Maths and Sciences

Based on interviews held by McIver Consulting, engineering students were found to have an interest in Leaving Certificate maths, physics, chemistry, applied maths, engineering, technical drawing and construction studies when at school and Cannon noted that engineering students also performed well in maths at high school (Cannon et al. 2000). Drew noted that for engineering students 'being good at maths' was an important reason for choosing engineering at third-level (Drew. 2003).

Even if girls are given the opportunity to study maths and science subjects, they still do not take up some of these subjects in the same proportion as male pupils. A reason for this lack of take up could be that maths, physics and chemistry are perceived as 'difficult' (Task Force on the Physical Sciences 2002) or 'hard' subjects (Peters et al. 2002, Roberts 2001) and 'masculine' subjects (Tees 2002). There can be a perception that to study physics, one has to be an 'A' grade student (Evening 2000). Findings from chapter 2 and other reports such as McIver Consulting indicate that female pupils are now participating in Higher Level maths at nearly the same rate as male pupils yet the overall percentage of pupils is very low with less than 20 per cent of all pupils studying it for the Leaving Certificate. Female pupils are not however studying physics at the same rate as their male counterparts. Only 30 per cent of all pupils studying physics are female.

In New Zealand, the differential participation of men and women in engineering was traced back to their subject selection at the senior level cycle where male pupils continue to dominate the traditional 'male' subjects such as graphics and technology while female pupils dominate typing, home economics and art (Evening 2000).

Some research suggest that maths and science subjects are taught in a manner that is unattractive to girls, who veer away from science at options stages (such as choosing which subjects to study for the Leaving Certificate) because they consider science subjects to be 'boring' and cannot relate these science subjects as helping humanity in any way (Evening 2002). After investigating the Leaving Certificate maths paper, Elwood noted that there was an absence of everyday 'real life' situations and

'problem solving' is interpreted as 'applying procedures and giving examples to students to solve' (Elwood et al. 2003).

Furthermore, engineering is not seen as a subject or a career path that contributes strongly to society. This needs to be addressed if pupils are to see engineering as having a key role in contributing to a knowledge-based society.

3.4.4 Exam Performance

There has been much discussion of gender issues in relation to the textual content and format of exams, textbooks, lessons and whether these contribute to gender differences in maths and science performance. It is generally accepted that girls perform better in open-ended questions while boys perform better on multiple choice questions (Clewell et al. 2002). Items favouring boys have tended to call on knowledge acquired through extracurricular activities, while girls are 'least disadvantaged' on items more heavily dependent on school-based knowledge (Clewell et al. 2002).

3.4.5 Textbook Bias

A factor that affects girls' low participation in engineering is the subtle bias towards men that is found in the contents of textbooks. Men are pictured more often than women and shown in more active roles. For example, there is little reference to women who have accomplished great achievements in engineering (Bailey et al. 1992, Potter et al. 1992).

3.4.6 Classroom Experiences/Bias

Science teachers, in particular female science and physics teachers, have been cited as having a potentially positive influence on female students when deciding to study engineering since female students feel that science teachers at least know and understand what an engineer does (Wharton 2001).

Aware of that positive influence on career decisions, researchers have noted that girls receive less attention than boys in the classroom when science subjects are taught and are often encouraged by their teachers to do subjects that would be more suited to their gender. Unlike boys, girls are not encouraged to investigate 'hands on' nature of mechanical and practical problems in laboratory settings. A report by the American Association of University Women (AAUW) presents findings that teachers can bring their own prejudice and bias into the classroom by allowing boys to dominate a classroom leaving girls to feel invisible or unimportant (Bailey et al. 1992). Pluckers study of 56 maths and science teachers found teachers believed that boys are more interested, more confident, and higher achievers in science, mathematics, engineering and technology (SMET) than girls (Plucker 1996)

Teachers are in unique position to advise students to move to Higher Level (higher tier) subjects or remain in Ordinary (intermediate tier) level. In her study, Elwood found that the different entry levels interacted significantly with teachers' stereotypes of boys' and girls' achievements to the extent that opportunities for success tended to be limited differentially for boys and girls. Teachers' decisions on which tier a student should enter were often based on 'affective factors' such as: a teacher's own attitude to subjects; the perceived ability of the students; confidence or anxiety within subjects. As Elwood suggests 'even before students sit the Leaving Certificate examination, decisions are made that determine inequality of opportunities' (Elwood et al. 2003)

Clewell, in her review of literature relating to women's entry into science and engineering fields, concluded that teachers hold disparate beliefs about male and female students, tending to stereotype maths as a 'male domain', to 'overrate male student's capacity with maths and to hold higher expectations for male students and to have a more positive attitude towards their male students (Clewell et al. 2002).

3.5 Career Guidance and Guidance Counsellor Influences

Gender stereotypes about careers still limit girls' interest and participation in different career options. Career development programmes usually begin in adolescence, thereby missing opportunities to reach primary school pupils before gender socialization and stereotyping becomes a strong counter influence on career decisions. Gender stereotypes on the parts of students, teachers, counsellors and parents play a role in determining whether pupils see a career as open and inviting or unattainable. Developing a limited sense of career capabilities and options at such a young age leads girls to have lower expectations about their abilities and steer away from male-dominated careers (Center 2002).

Career guidance and counselling which are interventions in the career development process, are essential in helping students choose their educational and career paths. Research on career development was conducted on white males and then generalised to other groups without taking into account the complexities of factors such as gender discrimination, sex stereotyping and socio-economic status (Center 2002). Research indicates that while college women have similar career expectations to men, they perceive role conflicts and see family issues as potential career barriers.(Dietz et al. 2002, Fielden et al. 2001).

A recent Irish study suggests that guidance counsellors are a major influence on pupil's career decision making (Gibson 2003). The Task Force for Physical Sciences noted that guidance counsellors were also the most useful source of career information for students (Task Force on the Physical Sciences 2002). Studies in New Zealand concur with this finding showing that guidance counsellors are also an important source of career information for students (Chalmers 2001).

In contrast other reports have noted that guidance counsellors are not seen as supportive because they do not know much about engineering or because they had a very stereotypical idea of who should be an engineer and who should not be an engineer (Wharton 2001, Austin 1995, Goodman et al. 2002). A recent report suggests that while guidance counsellors may be influential in guiding career decisions there is evidence that they may not be well prepared to discuss engineering as a career option (McIver 2003). This lack of preparation may be due to the fact that the day-to-day work of an engineer is not visible publicly and may be difficult to explain to a student (McIver 2003).

This understanding of what an engineer does is critical for female pupils in particular as evidence suggests that these girls do not have prior experience of engineering and hence need clear explanations. Career development programs such as guidance counselling at schools must work to reduce career stereotype through exposing pupils to a wider variety of work environment, role models and mentors.

3.6 Social Issues Relating to Women in Engineering

3.6.1 Parental Influences

Girls and boys receive different messages from peers, parents, teachers and society in general about appropriate roles in society and the definition of success relating to each gender. Parents tend to have low expectations of their daughters' success in maths and science even when, nationally, female pupils' examination performance exceeds that of their male counterparts (Clewell et al. 2002, Rosati 1997).

The role of parents is important in providing young girls out-of-school experience and integrating their classroom lessons with extracurricular activities. Cannon's study of engineering students in the Faculty of Engineering in Calgary noted that significantly more female students had a father who was an engineer (Cannon et al. 2000) and Rosati's study in Ontario reproted similar findings (Rosati 1997) Female engineering students also reported that their mother was a stronger positive influence in their career decisions compared to male students (Cannon et al. 2000, Goodman et al. 2002) while Goodman found that either parent can be a strong source of encouragement (Goodman et al. 2002).

3.6.2 Image is Everything

For many people, engineering is secure in its position as the last bastion of the male dominated industries, unable to 'shake off' the image of an unsuitable career for a woman (Garrod 1998). When Yurtseven (2002) states that the US public see an engineer as 'predominantly male, too bright for their own good, honest to a fault, non communicative, dull and loners' it is difficult for female pupils to form a union between the image of engineering and femininity. The Task Force for Physical Sciences report secondary level students perceiving the work of a scientist to be 'difficult, complicated, boring and poorly paid'.

The term 'engineer' is often understood as someone who does manual work, spending their time working on machinery. This misleading 'grease behind your fingernails' image can deter girls, and boys, from engineering and does not accurately represent the profession which has undergone dramatic change over the past twenty years. The role of an engineer has evolved, with the advancement of technology, from 'an independent, self-sufficient and highly motivated inventor to an inter-dependent team member of a corporate world' (Yurtseven 2002). The public's perception of an engineer has changed over the years from a 'know-it-all inventor and tinkerer' to a highly skilled and narrowly specialised technical expert (Yurtseven 2002).

Engineering is not seen as a professional career compared to law, accounting and medicine (Evening 2000). Hirsch's study of high school students suggest that even students who have a positive attitude towards engineering, and are considering studying engineering, know little about engineering careers and what engineers do (Hirsch 2003).

3.6.3 Lack of Experience with Engineering Toys

Some researchers theorise that there is a biological or genetic difference, which directly accounts for most sex differences in maths and science related achievement and hence subsequent participation in engineering. Most of the theories relate to spatial abilities, examples of which include:

- "*Different prenatal or pubertal hormone exposure causes gender differences in visual-spatial and verbal ability*". (Rosser 1997).
- "*Since both spatial and mathematical abilities are functions considered more efficiently carried out by the right hemisphere [of the brain], males' significantly higher right than left hemispheric ratios for neuronal density and neuronal numbers could contribute to gender differences in these areas*" (De Courten-Meyers 1999).

There is some evidence of gendered innate spatial abilities. Yet, researchers do suggest that boys engage in play activity that tends to exercise their spatial visual skills while girls tend to exercise their verbal skills (Sadker et al. 1991).

Male children more frequently have early extracurricular activities (playing with maths and scientific type toys) that develop mechanical inquisitiveness and problem-solving skills. Female children typically have fewer play experiences that build spatial and physical concepts. Their play experiences tend to be stationary, stimulating very little interest in the physical laws of nature (Hensel 1989). Other researchers support this finding by stating that out-of-school experiences for boys and girls may contribute to preferences, with boys playtime involving 'tinkering' and girls tending to more biological science activities such as the 'study of flowers, bird watching or butterfly collecting' (Clewell et al. 2002).

If pupils feel they lack good spatial visualization they may see this as a reason for not studying engineering, Sorby (2001) highlights a course to help improve both male and female spatial visualization to aid students in their engineering courses and found it be successful.

3.6.4 Loss of Self-Esteem as a Teenage Girl

As a group, girls experience a dramatic loss of self-esteem when they enter adolescence. Some of this loss can be attributed to the over-emphasis on a girls' image, peer pressure and missed messages that girls receive from the media/society on women's role (Bailey et al. 1992). This loss of self-esteem and confidence may help explain why girls behave as a group and are more concerned with their friends and what their friends are doing, rather than having the confidence to choose subjects that are non-traditional for girls. Bailey et al (1992) claim that boys not to lose their self-confidence throughout the teenage years to the same degree.

3.6.5 Lack of Role Models

Sullivan et al (2003) suggest that one reason why pupils do not enter engineering is because of lack of role-models. When the profession of engineering is dominated by men and the consequent image is masculine it is very difficult for female pupils at post-primary level to see themselves in the profession (Beder 1998). Also women in many countries lack contact with engineering role models thus making it more difficult for them to believe they can achieve their ambition (Tees 2002). Role models and mentoring schemes are examples of positive action measures where role models can be given a high profile, for example, on national radio or television to demonstrate that it is possible for an engineer to be successful and be a woman. (Tees 2002).

3.7 Conclusions

- No previous national study of the under-representation of girls in engineering has been undertaken in Ireland. It is long overdue, given the small proportion of women entering into engineering. Three main reasons why an increase in the participation of women in engineering is necessary concentrate on:

    - gender parity or equality;
    - the changing nature of engineering and
    - the shift towards a knowledge intensive society.

- Despite the evident deficit of women in engineering professions/courses, research studies that focus *exclusively* on the factors that hinder female secondary schools from choosing engineering are scarce. Much research looks at factors that encourage female students to stay in engineering or science once they are studying at third-level. Such retention factors include positive images of scientists and engineers, support of women's equality, and positive classroom experiences. Other research has investigated the educational climate/culture for women studying in predominantly male engineering courses, with a view to suggesting strategies to combat any difficulties female students may encounter.
- Researchers have explored the issue of self-efficacy, defined as the self-perception of a student's ability to learn engineering against the student's actual ability to learn in engineering. Measures to increase female students' self-efficacy within engineering include collaborative learning practices to allow 'critical thinking'.
- The secondary level maths and science curricula may discourage female students from considering engineering at third level due to the current emphasis on 'chalk and talk' blackboard culture in stark contrast with more experimental methods that emphasise problem-solving skills and 'learning by doing'. Other research highlights textbook bias where men are pictured more often than women and shown in more active roles.
- Classroom experience may affect girls where they receive less attention than boys in the science classes and are encouraged by their teachers to study subjects that would be more suited to their gender. Teachers' decisions on which level a student should study a subject (e.g. Ordinary or Higher) are often based on 'affective factors' such as: the teacher's own attitude to subjects; the perceived ability of the students; confidence or anxiety with the subjects.
- Some literature stresses that the role of guidance counsellors is influential in guiding pupils in their career decisions. The role of the parent is seen as important in providing young girls with out-of-school experience and integrating their classroom lessons with extracurricular activities. Male children tend to get more early extracurricular activities that develop mechanical inquisitiveness and problem-solving skills while female children typically have fewer play experiences that build spatial and physical concepts. Girls' play experiences tend to be stationary, stimulating very little interest in the physical laws of nature.
- The lack of role models of women in engineering occupations/studies has been identified as a factor that may inhibit the interest and careers of girls at secondary schools.

4. Survey of Guidance counsellors in Post-Primary Schools

4.1 Survey Objectives

As noted in Chapter 3, guidance counsellors have been noted as exerting a major influence on post-primary pupil's career decision making (Gibson 2003) and are a useful source of career information at this level (Task Force on the Physical Sciences 2002). Conversely there is a view that guidance counsellors have not been supportive of girls entering engineering, due to their being unaware of what an engineer does and/or holding stereotypical views on who should be an engineer (Wharton 2001, Austin 1995, Goodman 2002).

The research objective for this study was to investigate the factors that encourage and discourage female students from entering third level engineering courses. Since guidance counsellors play a key role in influencing secondary level pupils, it was hypothesised that they could be instrumental in dis/encouraging pupils to study engineering. The functions that guidance counsellors perform include: counselling pupils on personal matters, discussing career and educational issues; testing (e.g. Differential Aptitude Test for Guidance, commonly known as DATS); providing career information; liasing with parents and staff; preparing pupils for job search skills; work experience and/or conducting mock-interviews. Some qualified guidance counsellors have other roles within a school which may include library duties or teaching.

Since guidance counsellors are the information providers to pupils about careers within schools, a postal survey of guidance counsellors working in post-primary schools was undertaken to establish:

- what guidance counsellors knew about engineering;
- why they think pupils choose engineering or otherwise;
- the preferred system of entry to engineering courses and why;
- the usefulness of information on engineering;
- who the most influential person are for pupils when choosing their careers;
- what could be done to encourage female pupils into engineering.

4.2 Survey Methodology

The survey of guidance counsellors was conducted using a postal questionnaire for self-completion, in May 2003. The Institute of Guidance Counsellors in Ireland provided a list of members that included the sampling frame of guidance counsellors who teach in post-primary schools only.

Prior to the design of the questionnaire, two guidance counsellors were interviewed to obtain information about their role in schools and on constraints in their tasks. Once designed, the questionnaire was piloted by sending it to five guidance counsellors drawn from contacts made during Trinity College's Open Day events.

The revised and final questionnaire (Appendix A) was sent out on 13th May 2003 to 1,020 guidance counsellors, accompanied with a letter on headed: Department of Statistics, Trinity College Dublin, note paper and individually signed (Appendix B). This letter set out the objectives of the survey and

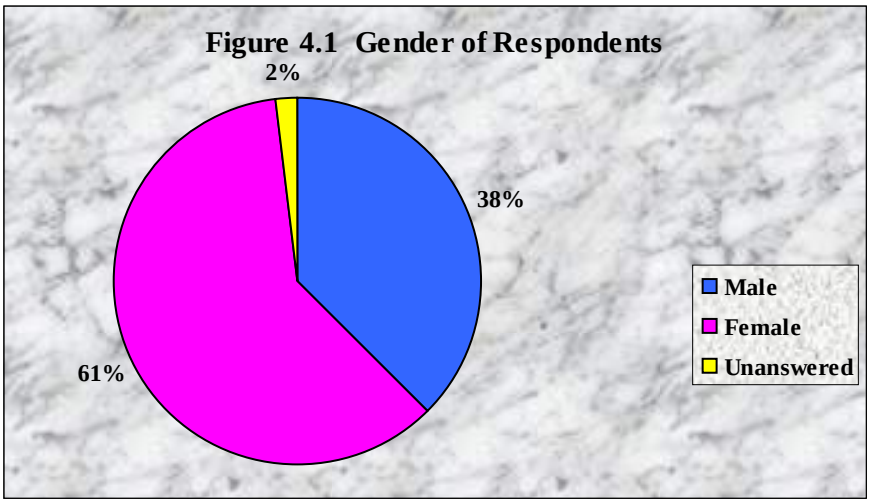
urged the recipients to respond by completing and returning the questionnaire using a FREEPOST return envelope. A total of 224 questionnaires were returned to the Department of Statistics, Trinity College, Dublin, a response rate of 22 per cent. This response rate is satisfactory for a self-completion postal questionnaire survey

4.3 Profile of Respondents

This Section sets out the profile of guidance counsellor teachers who responded to the survey, according to gender, length of service as guidance counsellors, and whether they were are engaged on a full or part-time basis. The analysis is based on the responses of 222 guidance counsellors since two respondents omitted to provide information on their gender.

4.3.1 Gender of Respondents

The 224 responses to the questionnaire included 85 men (38% of total) and 137 women (61% of total). Two respondents did not state their gender (Figure 4.1).



4.3.2 Length of Service in Current School

The survey indicates that female respondents have worked fewer years as guidance counsellors in their schools than their male counterparts, with half having worked for less than ten years compared with 36 per cent of the men (Table 4.1).

In contrast, 13 per cent of women have worked for 20-29 years in their current role compared to 40 per cent of male respondents. These differences are statistically highly significant.

Table 4.1 Length of Service as Guidance Counsellor

Years	No. Men	% of Men	No. Women	% of Women	Total
0- 9 years	31	36%	69	50%	100
10– 19 years	15	17%	42	31%	57
20-29 years	33	40%	18	13%	51
Over 30 years	5	6%	4	3%	9
Not stated	1	1%	4	3%	5
Total	85	100%	137	100%	222

Chi-square test* .000

4.3.3 Subjects Taught

Only a small number of the respondents teach maths (28) or 13 per cent of the total. Even fewer (8) guidance counsellors teach physics, six teach technical drawing and five teach chemistry. None of the respondents teach applied maths or chemistry.

4.3.4 Working Time Arrangements

A total of 158 respondents (70%) work full time while the remaining 64 guidance counsellors (30%) work part-time. There is no significant difference between working time arrangements and gender.

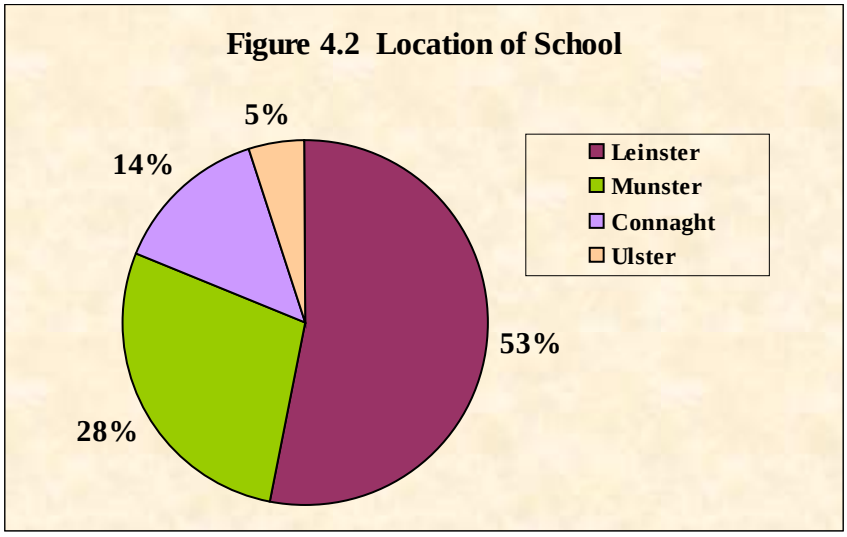
4.4 Profile of Schools

Section 4.4 provides information on the geographical location and school type for the schools in which the guidance counsellors are employed.

4.4.1 School Location

Information was sought on where the respondents' schools are located. The survey shows that most respondents' (53%) are employed in schools located in Leinster (including 31% in and 22% outside Dublin), followed by the Munster (28%), The remaining 19 per cent of respondents teach in schools located in Connaught (14%) and Ulster (5%) (Figure 4.2).

* Unless otherwise stated, all of the statistical tests referred to in this study are based on Pearson's chi-square test.



4.4.2 Type of School

Guidance counsellors were asked what type of school they work in. More than half of them (51%) work in vocational schools, while one-quarter (25%) work in secondary schools and a similar proportion (24%) guidance counsellors work in community/comprehensive schools.

The majority of respondents (65%) work in all-girls schools while nearly a quarter (24%) work in all-boys schools. The remaining 11 per cent of respondents work in co-educational schools. Ninety per cent of respondents are working in non-fee paying schools with the remaining 10 per cent of respondents work working in fee paying schools. Three-quarters (75%) of respondents are employed in Roman Catholic schools, compared with 5 per cent in Protestant schools, while one-fifth work in non-denominational schools (20%).

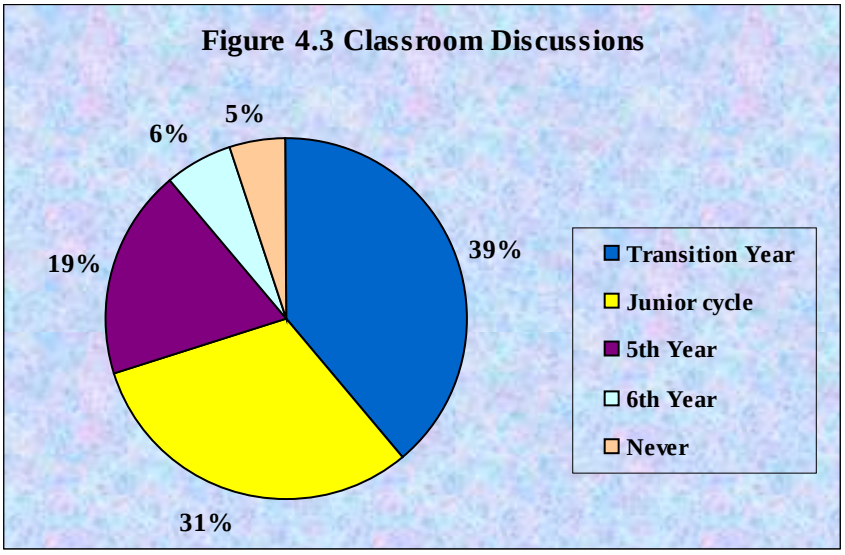
4.5 Guidance Counsellors Experience of Engineering

Section 4.5 concentrates on the nature and timing of contact/discussions between guidance counsellors and pupils and whether information on all of the engineering disciplines are available to Leaving Certificate pupils.

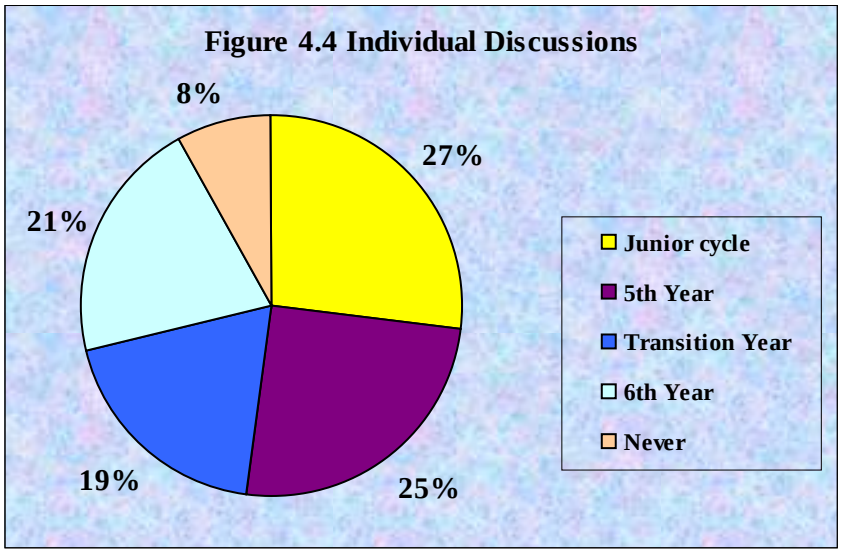
4.5.1 Introducing Pupils to Engineering

Guidance counsellors were asked when they introduce the *theme of engineering* as a career to their pupils, through classroom discussions and individual discussions.

Of those who responded to this question, 38 per cent introduce career discussions during Transition year and 31 per cent during the Junior Cycle while. One-quarter (25%) introduce classroom career discussions during the Senior Cycle (fifth and sixth year). Five per cent of respondents stated that they have never had classroom discussions about engineering careers (Figure 4.3).



Fewer guidance counsellors introduce individual sessions (28%) with their pupils in the Junior Cycle compared with classroom discussions (31%). Nearly half (46%) of the guidance counsellors who responded organise these individual career meetings with pupils during fifth or sixth yea (Figure 4.4).



4.5.2 Access to Engineering Careers Information

Guidance counsellors were asked if Leaving Certificate pupils in their school have access to career information on nine disciplines of engineering. Almost nine out of ten of respondents claim that their pupils do have access to all nine disciplines of engineering (Table 4.2).

Table 4.2 Availability of Information on Engineering Disciplines

	Number	%
Mechanical	209	93%
Electrical	204	91%
Computer & Software	205	91%
Civil & Structural	204	91%
Electronics & Micro-Electronic	200	89%
Biomedical	200	89%
Chemical & Process	198	88%
Building Services	192	86%
Agricultural & Food	192	86%

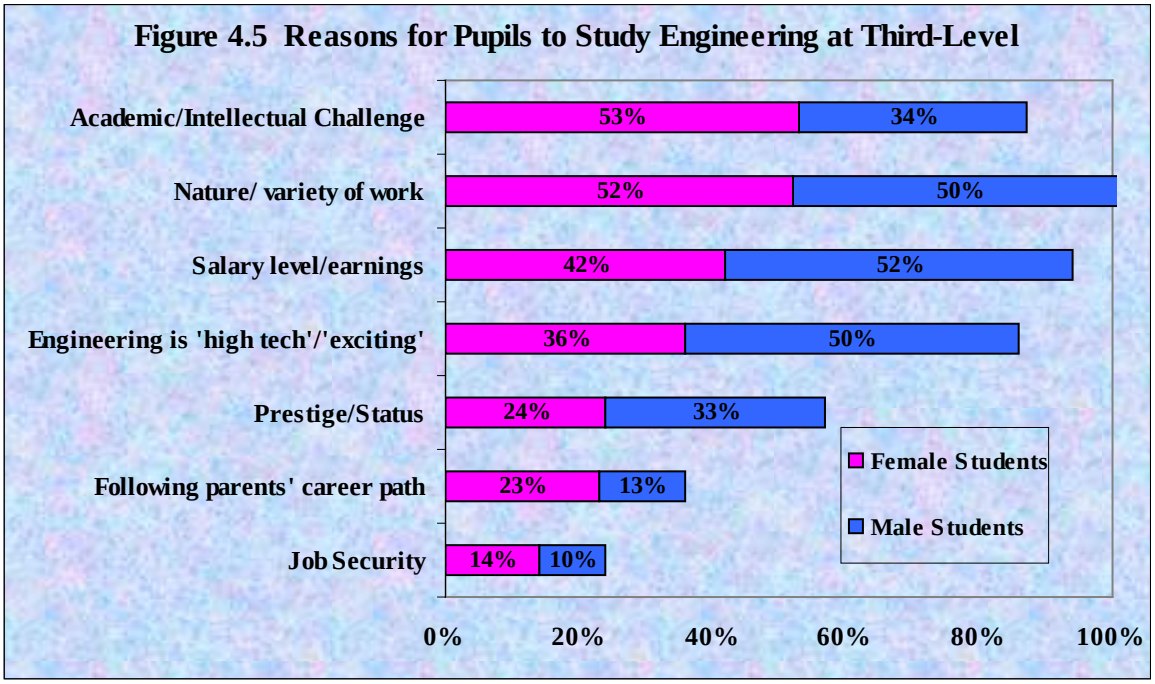
4.6 Pupils' Choice of Engineering at Third-Level

4.6.1 Reasons for Studying Engineering at Third-Level

A list of potential motivating factors were presented to guidance counsellors who were then asked to rank the factors that they consider most *important to male and female pupils* deciding to study engineering at third-level.

Figure 4.5 indicates that the two most important reasons that *female pupils* would want to study engineering are: "academic achievement and the intellectual challenge" (53%) and "nature and variety of work" (52%). These are followed by "salary level" (42%) and "engineering as high tech and exciting" (36%).

In contrast "academic achievement" was ranked highest (52%) by guidance counsellors as the main reason for *male pupils* wanting to study engineering, followed by and "nature and variety of work" (50%) and "engineering as high tech and exciting" (50%).



Other factors that guidance counsellors felt might encourage *female pupils* to study engineering were:

"role models"; "that it is not noisy, greasy and using milling machines"; "attending talks, open days on engineering"; "social value of work"; "study subjects that are directly related to engineering, thus improving their aptitude and confidence for this area"; "understanding what is involved in careers in engineering, still seen as a 'male' preserve".

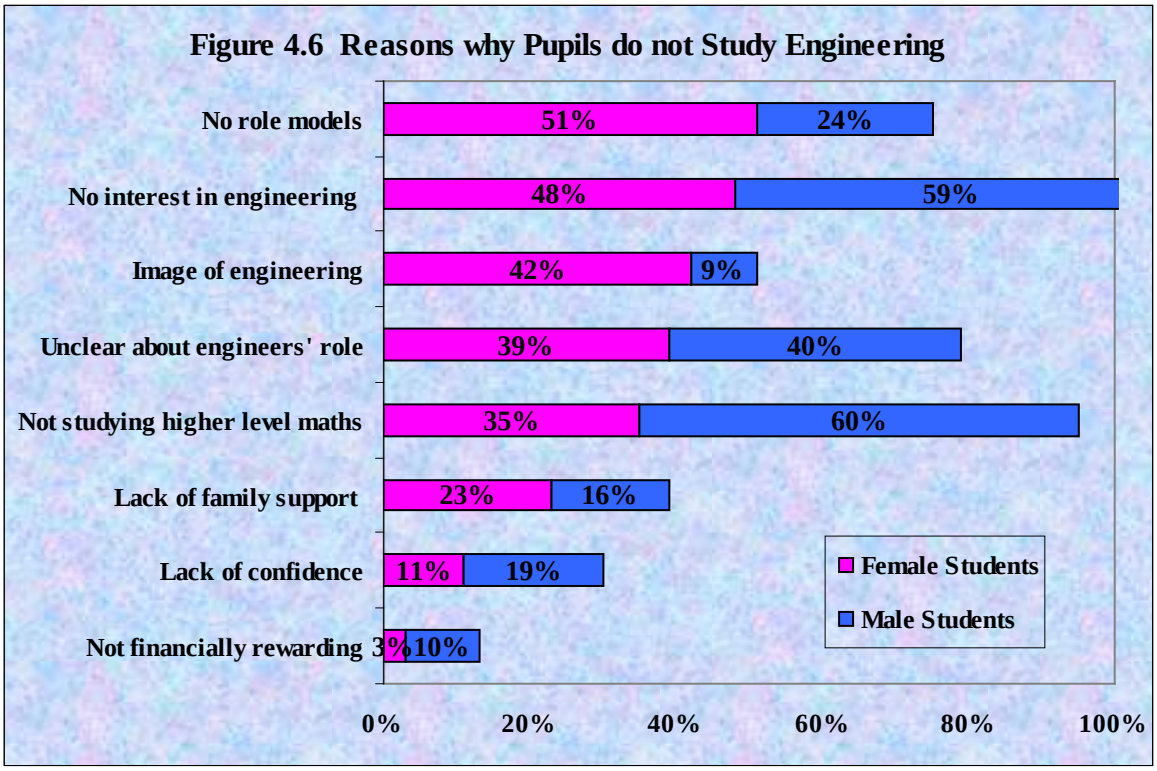
In order to encourage more *male pupils* to study engineering, careers guidance counsellors mentioned:

"Interest in maths and physics"; "interest in problem solving"; "high interest in cars or aircrafts or engineering as a school subject"; "interest and experience on sites".

4.6.2 Negative Factors that Discourage the Study of Engineering

A list of potentially discouraging factors were presented to guidance counsellors who were then asked to rank which factors might deter male and female pupils from pursuing engineering at third-level. According to over half (51%) of the guidance counsellors, the main reason why *female pupils* do not enter engineering is because there are no role-models for them in the profession. Just under half the respondents (48%) stated they felt female pupils do not enter engineering because they simply have "no interest in engineering as a career". More than two-fifths (42%) felt that the "image of engineering" is a discouraging factor for female pupils (Figure 4.6).

In contrast, "not studying Higher Level maths" is perceived to be the most discouraging factor for male pupils, with 60 per cent of guidance counsellors feeling this was the reason that male pupils do not study engineering. This was followed closely by the opinion that many male pupils have "no interest in engineering as a career" with 59 per cent considering this to be a discouraging factor. Only 9 per cent of respondents felt that the "image of engineering" is a discouraging factor for *male pupils*.



Other factors that might discourage *female pupils* from studying engineering include:

> *"inability and discouragement from parents/students/staff"; "perhaps the gender and background of the guidance counsellor"; "still seen as a male career and perhaps not offered physics or other science subjects in school"; "many students choosing Business and Legal courses as more clear-cut, no practical!"; "social dimension, interaction with people and social usefulness not emphasised"; "view it as a difficult option".*

Guidance counsellors felt that other factors that might discourage *male pupils* from studying engineering were:

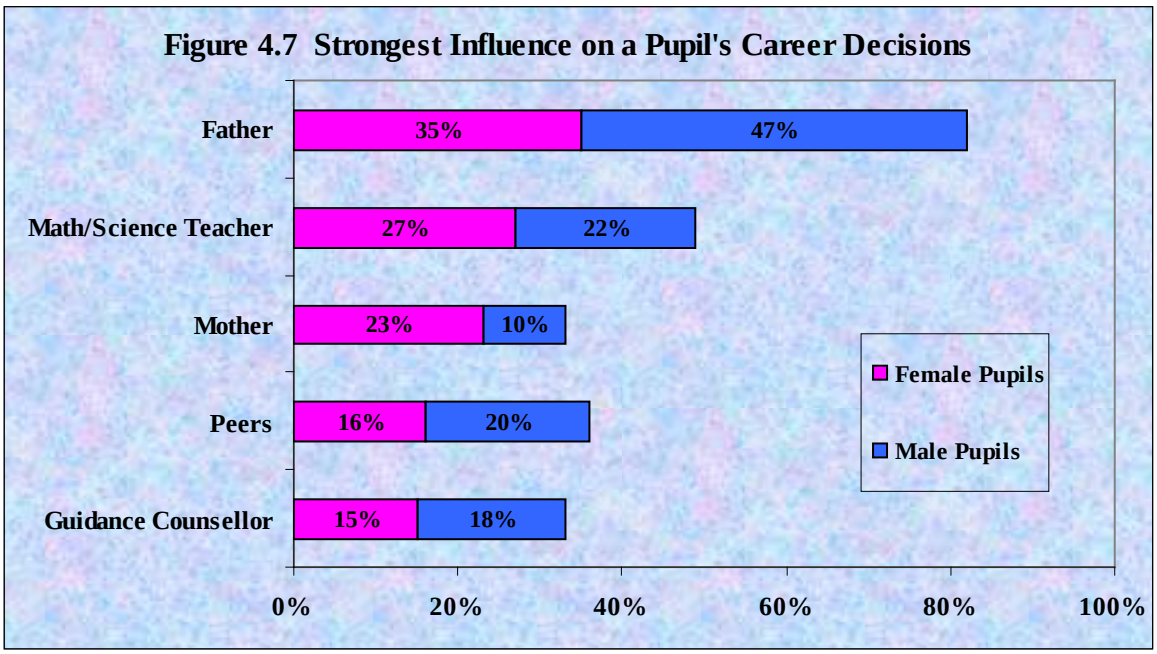
> *"considered to be difficult"; "no experience of technical problem solving"; "weak at science"; "lack of knowledge of what is actually involved in the courses and what careers they lead to"; "low numerical and mechanical aptitude".*

4.7 Career Influences for choosing Engineering

Guidance counsellors were asked to rank the people who they are the most influential in plans for a career in engineering. Seventy-seven respondents (47% of total) felt that fathers are the most influential person for *male pupils* and 61 respondents (35% of total) ranked fathers as the most influential person for *female pupils*. Guidance counsellors ranked Maths/Science teachers as the next strongest influence for *female pupils* (27%) and *male pupils* (22%) in deciding to study engineering. Mothers were regarded as next most important for *girls* (23%) but not boys (10%) (Figure 4.7).

Other positive influences/people noted by guidance counsellors were:

> *"clear information from schools and colleges"; "engineering teachers"; "engineering professionals via STEPS, open days etc"; "engineers themselves"; "extended family members/family/siblings contacts in the engineering profession"; "female engineers"; "inspirational speakers; peer role models (e.g. past pupils)"; "school tradition of studying engineering – links with universities through past pupils or academic staff; subjects studied at leaving certificate"; "neighbour"; "media"; "television soap with engineers as role model – good looking, cool etc."*

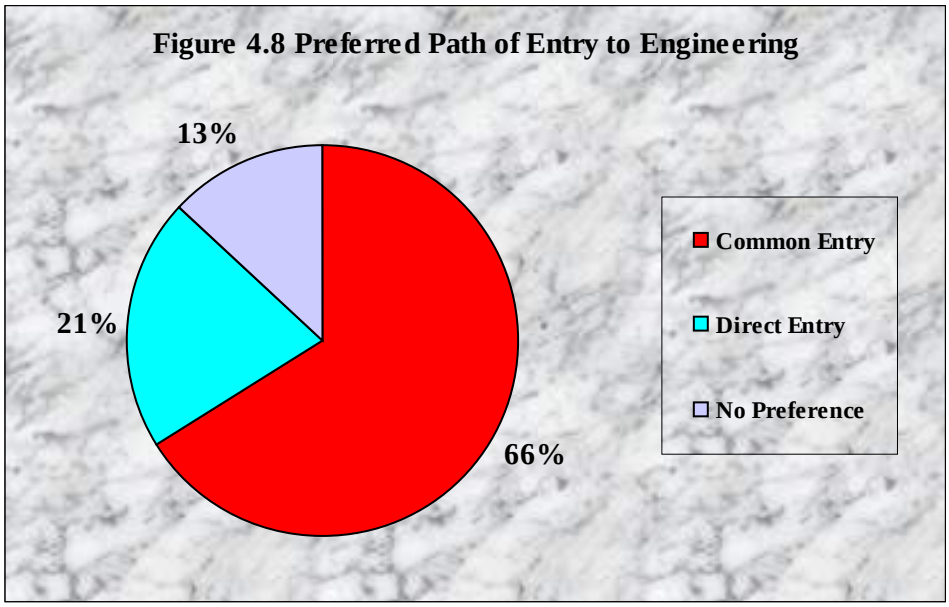


4.8 Preferred Path to Study Engineering at Third-Level

There are two different approaches to choosing engineering at third-level. These are: 'Common Entry' and 'Direct Entry'. Common entry is defined as where the 'student undertakes one to two years of a common course before choosing a particular discipline (e.g. mechanical engineering). Direct Entry is defined as where the 'student undertakes his/her chosen discipline (e.g. mechanical engineering) from the start of their engineering courses. For example, Trinity College offers common Entry for their engineering courses while UCD offers direct-entry.

The available literature suggests that pupils may not be able to decide what area of engineering they wish to study due to lack of experience, knowledge or role-models in the field. It is argued that direct entry may deter some pupils choosing engineering, as they are not prepared to make a full decision before they enter college.

Guidance counsellors were asked to draw upon their experience of dealing with pupils and state which entry they felt their pupils prefer. The majority (66%) felt that pupils prefer common entry to engineering with only one-fifth of respondents (21%) favouring direct entry (Figure 4.8).



4.8.1 Common-Entry Engineering

Guidance counsellors were also asked to comment on why they felt their pupils preferred the common entry method. The main reason was that pupils prefer this because it allows them to keep their options open and not specialise too early, especially if they have no prior experience or knowledge of engineering. Typical of these responses were:

> *"allows them to experience different types of engineering and chose later a specialist route"; "they can sample each [type of engineering] and then decide while one to elect"; "gives students further exploration of engineering branches before they lock in"; "in 32 years, I rarely find students able/ready to choose career destination, [they] are willing to take the initial step but premature to make final decision"; "lack of awareness of specific nature and requirements of denominated courses, Common Entry keeps more options open"; "it gives them a year to see which area they are suited to, a year older, a year wiser";*

Other guidance counsellors stressed pupils' lack of experience or knowledge of engineering:

> *"many students know they would like to study engineering but are not sure which branch to specialise in, Common Entry gives them the time to choose with confidence"; "most pupils need a year to get their experience before deciding in a specific field of engineering"; "most students don't have any relevant experience"; "rather too specific, no seventeen year old knows such specific information [about engineering]".*

4.8.2 Direct-Access Engineering

Other guidance counsellors felt their pupils' prefer direct-entry engineering courses because they believe that pupils considering engineering have completed sufficient research to know which discipline is right for them:

> *"most of the students would have researched engineering and have had made a decision"; "having read and researched engineering, the majority would know which area they wish to pursue"; "many would be well-informed"; "the majority of students interested in engineering are interested in one specific area of engineering"; "students choosing engineering have already decided what career they want, they are very focused individuals".*

Others felt that pupils already have enough experience gained to know about engineering:

> *"usually it is boys who choose and they have subject backgrounds in engineering, construction studies, technical drawing"; "the wide choice of subjects offered by the school helps students choose areas of study of their choice".*

It was also noted that many pupils do not have a choice due to the location of the nearest University/IT to pupils:

> *"only direct-entry courses are available in our local third-level institutions – this is what they know"; "no Common Entry in UCC and [pupils] slow to go to UL or UCD"; "in our area, the majority of engineering courses are Direct Entry – location is a factor"; "no Common Entry in Cork"; "our student population is situated in Cork – this is the type of entry they know".*

4.9 Contact with Schools by Engineering Stakeholders

Guidance counsellors were asked to comment on whether they had been contacted by engineering stakeholders during the past year to discuss careers in engineering for the pupils in their schools. The key stakeholders being:

- Engineering companies
- Universities and Institutes of Technology (collectively known as Third-Level Institutes)
- Engineering initiatives orchestrated mainly by the Institution of Engineering in Ireland (IEI).

4.9.1 Contact with Engineering Firms

When asked whether engineering firms had made contact with their school during the past academic year to discuss engineering as a career for the pupils in the school, only 38 (19%) had been contact ed by an engineering firm(s) over the past year. In contrast, 163 respondents (81%) had not had any contact with engineering firms. Appendix C contains a list of some of the companies that have contacted schools in the past academic year.

4.9.2 Contact with Third-Level Institutes

Guidance counsellors were asked whether Third-Level Institutes had made contact with their school during the past academic year in order to discuss engineering as a career for pupils. Over three-quarters (77%) of guidance counsellors been contacted by Third-Level Institutes.

Respondents were asked to state, which Universities and Institute of Technology had been in contact with them during the past year to discuss engineering as a prospective career for the pupils in their school (Table 4.3). University College Dublin (UCD) has been in most contact with guidance counsellors (63 respondents) followed by University College Cork (48 respondents). Trinity College Dublin had the lowest contact for any university (34 respondents).

Table 4.3 Contacts with Universities

University	Number	%
University College Dublin	63	28%
University College Cork	48	21%
National University of Ireland, Galway	46	21%
Dublin City University	43	19%
University of Limerick	38	17%
Trinity College Dublin	34	15%

The Dublin Institutes of Technology (including Tallaght, Kevin Street,) had made the most contact with guidance counsellors to discuss engineering as a career with their pupils. Twenty nine per cent of guidance counsellors had contact from DIT, Dublin followed by Cork (14%). Letterkenny IT had least contact with only 4 respondents stating that it had made contact with their school.

Table 4.4 Contacts with Institutes of Technology

Institutes of Technology	Number	%
Dublin	64	29%
Cork	32	14%
Athlone	31	14%
Dundalk	22	10%
Carlow	17	8%
Sligo	17	8%
Limerick	15	7%
Waterford	13	6%
Galway-Mayo	11	5%
Tralee	6	3%
Letterkenny	4	2%

4.9.3 Contact with Engineering Initiatives

Science, **T**echnology and **E**ngineering **P**rogramme for **S**chools (STEPS) is an initiative set up by the Institution of Engineers in Ireland (IEI) with the aim of informing young people of the challenges and opportunities presented by science, engineering and technology with a view to increasing pupils' awareness of the benefits of choosing engineering as a career.

The STEPS programme is organised by the Institution of Engineers of Ireland in partnership with the Department of Education and Science, Forfás, Fás, and numerous leading high technology industries (Appendix D). The programme aims to redress the shortage of engineer's problem by:

- increasing public awareness of the value of the engineering profession as a career; making information available on engineering as a career for all interested parties;
- initiating and developing projects that will encourage more pupils to study science, technology and engineering related subjects at school/college;
- promoting the take-up of science, technology and engineering subjects among girls.

Highlights of the STEPS programme include:

STEPS Seminars:

Designed for pupils, guidance counsellors and parents. The Seminars consist of 6 short 15-20 minute presentations on the different disciplines of engineering. Each presentation is given by recent engineering graduates working in industry.

STEPS School-Industry partnerships:

This partnership is aimed to encourage more co-operation between schools, colleges and local industries.

STEPS Engineer to School:

This is aimed at guidance counsellors, course co-ordinators, science, engineering, technology and other interested teachers regarding engineering as a career.

Junior Engineers for Ireland Challenge:

A national competition for primary schools to encourage imagination, creativity and ingenuity in pupils through engineering and design.

Classroom resource materials:

for teachers and pupils.

STEPS Competitions:

both school and out-of-school based.

The co-ordinators of STEPS have contacted 82 per cent of the respondents.

4.10 Usefulness of Engineering Materials promoted by Engineering Stakeholders

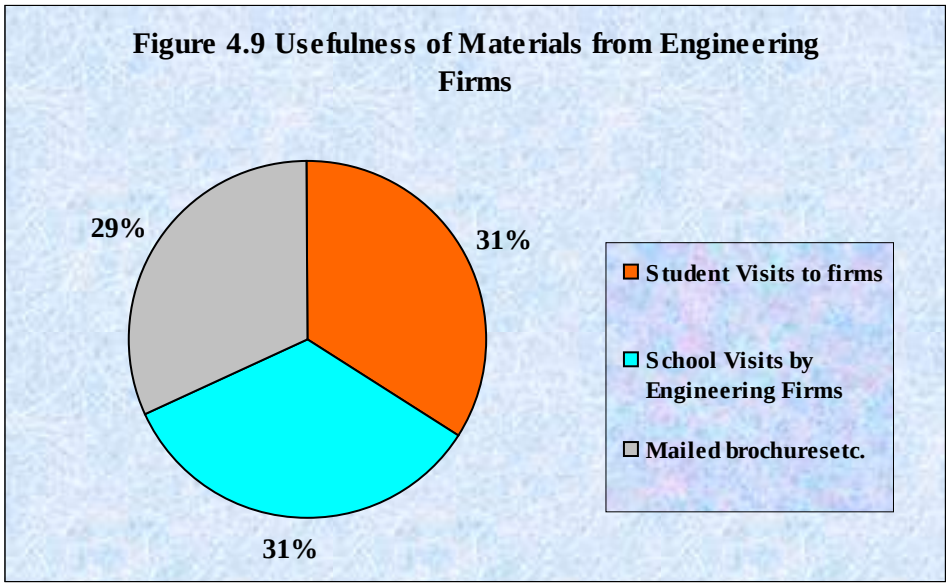
Engineering materials such as brochures, pamphlets and videos are promoted by the engineering stakeholders aimed at attracting the attention of post-primary pupils to consider engineering as a career. These brochures explain what each discipline of engineering is about, what an engineer does and what the pre-requisites are to study engineering. The engineering stakeholders also promote

interactive events such as engineering speakers at schools, pupil-visits to engineering firms, or engineering faculty departments. Guidance counsellors were asked to comment on how useful they found each of the promotional materials or events organised by each of the stakeholders.

4.10.1 Usefulness of Material/Events from Engineering Firms

Figure 4.9 shows that 29 per cent of all respondents found brochures/pamphlets and videos produced by engineering firms to be of use in promoting engineering. Nearly one-third (31%) found that a visit by a qualified engineer to the school has been useful and a similar proportion felt that visits by the pupils to the engineering firms were useful.

Figure 4.9 Usefulness of Materials from Engineering Firms



Guidance counsellors also mentioned:

> *"attendance at STEPS Roadshow"; "past pupils visits to schools"; "attend a careers evening for Leaving Certificate students and their parents"; "offer work experience".*

4.10.2 Usefulness of Material from Third-Level Institutes

From a list of source material and promotional activities issued by third-level institutes to promote engineering in post-primary schools, respondents were asked to comment on how useful they find each of the forms of communication. Nearly three-quarters (74%) of guidance counsellors found brochures/pamphlets and/or videos produced by Higher Education Institutions to be useful in promoting engineering for their pupils. Over two-thirds of respondents (66%) thought pupil day-visits to an engineering faculty to be a good method to promote engineering. Over one-quarter found *"student summer camp at a third-level institute"* a useful method to promote engineering (Table 4.5).

This low response to pupil summer camp may be due to the fact that there are few Higher Education Institutions that run summer camps hence guidance counsellors and their pupils have not had much experience of/with them.

Table 4.5 Usefulness of University/IT Initiatives

	Number	%
Brochures/Pamphlets/Videos	165	74%
Student day-visit to Engineering Faculty	148	66%
Talks to schools by engineering academics	143	64%
General open day to third-level Institutes	139	62%
Student Summer camp at a third-level Institute	61	27%

4.10.3 Usefulness of Materials from IEI and STEPS

Initiatives have been set up over the past years to promote engineering in post-primary schools aimed at male and female pupils. There have also been information booklets, videos, books and other material produced by these initiatives, which have been sent to guidance counsellors in schools. Guidance counsellors were asked how useful or otherwise they found these forms of information in promoting engineering as a career for their pupils.

The most useful material for promoting engineering is Professor Gerry Byrne's book called *'Engineering as a Career'*. Over three-fifths (61%) of all guidance counsellors found this book to be useful in helping their pupils understand what engineering is. The second most useful information on engineering careers is the STEPS information pack which is sent to the guidance counsellors in a booklet form. There is a separate sheet that describes what each of the disciplines of engineering involves and how one can pursue the specific branches of engineering. More than half (56%) found these information packs provided by STEPS to be useful (Table 4.6).

Table 4.6 Usefulness of STEPS/IEI Initiatives

	Number	%
'Engineering as a Career' by Professor Byrne	137	61%
STEPS Information pack (on each discipline)	125	56%
'The Worlds of Engineering' (CD-ROM)	87	39%
STEPS student booklet	76	34%
'Engineering Life' Magazine	60	27%
'Get SET' newsletter	56	25%
'Get SET' event calendar	56	25%
STEPS competitions	49	22%
'Archimedes Daughter' Video	50	22%

Guidance counsellors found the 'Get SET' calendar (25%) and the STEPS competitions (22%) least useful sources of information on engineering careers. Nearly three-fifths (58%) of the guidance counsellors did not receive the Department of Education video 'Archimedes Daughter' while nearly

half (48%) of the respondents did not receive the 'Engineering Life' Magazine which is a quarterly publication by STEPS.

4.10.4 Usefulness of STEPS/IEI Seminar

Respondents were also asked to describe the usefulness of seminars/partnerships arising from engineering initiatives in promoting engineering as a career. Nearly half of the guidance counsellors (47%) found the School-Industry Partnership, organised by STEPS, useful. The STEPS Partnership Scheme 'twins' post-primary schools with Ireland's leading engineering, technology and science firms for the purposes of facilitating pupil group visits.

Forty-four per cent of the guidance counsellors found the 'Careers in Engineering' Roadshow and the STEPS engineering seminars to be useful (42%). The least attended programme is the half-day teacher seminar to an engineering company. This is run by STEPS and allows guidance counsellors and science/math teachers to visit an engineering company and see how the company is run so that they can elaborate on their experiences to the pupils (Table 4.7).

Table 4.7 Usefulness of Seminars

	Number	%
School-Industry Partnerships	105	47%
"Careers in Engineering" Roadshow	99	44%
STEPS Engineering Seminars	93	42%
Half-day teacher seminar to Engineering company	67	30%

4.11 Further Actions to Promote Engineering for Female Pupils

Guidance counsellors were asked to draw upon their own experience in order to state whether they felt there were any actions that engineering stakeholders such as firms, third-level institutes and engineering initiatives could undertake to promote engineering specifically for female pupils.

More than two-thirds of guidance counsellors (141) agreed that *engineering firms* could put into place actions aimed specifically at female pupils. Over half the guidance counsellors (127) felt that there are certain actions *third-level institutes* could adopt in order to promote engineering specifically for female pupils. Over half of guidance counsellors (119) believe that there are certain actions STEPS or IEI could adopt in order to promote engineering specifically for female pupils.

4.12 Promotion Efforts aimed at Female Pupils

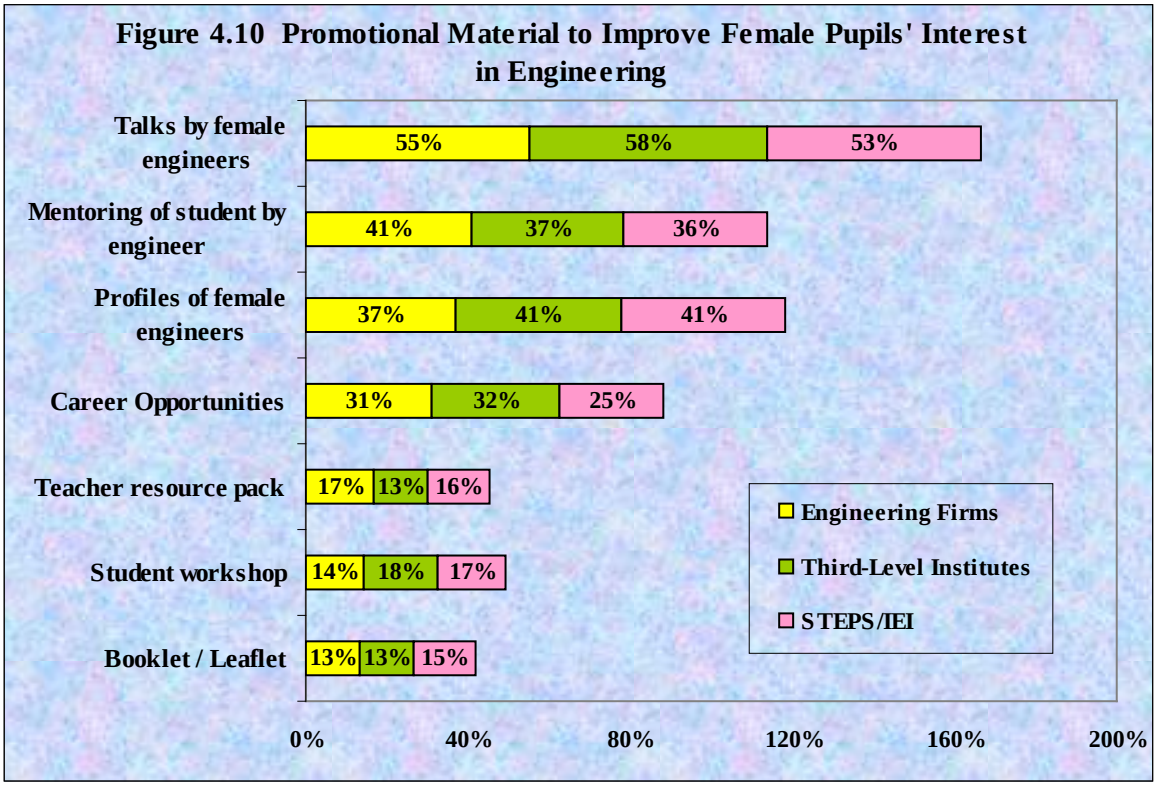
A list of initiatives/materials to promote engineering were presented to the guidance counsellors who were then asked to choose the three initiatives they felt could help promote engineering for female pupils by each of the engineering stakeholders.

Figure 4.10 illustrates that the most popular form of promotion is to have *"talks by female engineers at the guidance counsellor's school"*. Guidance counsellors felt that this is the most important issue for engineering firms (55%), third-level institutes (58%) and STEPS/IEI (53%) to consider when addressing the matter of promoting engineering for female pupils.

The next most popular promotional aid for engineering firms is to incorporate "*mentoring between students and an engineer*" with 41 per cent of guidance counsellors supporting this. This suggests that guidance counsellors feel the need for positive, personal interaction between schools and engineering firms. This feeling was reiterated by the focus group comments in chapter 6 and also in pupils' views of the Leaving Certificate Survey in chapter 5.

The next most popular promotional aid for third-level institutes (41%) and STEPS/IEI (41%) is to create positive profiles of female engineers, including the salary scale levels a female engineer should expect to earn.

Figure 4.10 Promotional Material to Improve Female Pupils' Interest in Engineering



Other promotional material that guidance counsellors' felt engineering firms should become involved with includes competitions (6%), www site (5%), poster campaign (4%), role-play or theatre (4%).

Guidance counsellors were asked to comment on any other actions by **engineering firms** they felt appropriate to promote engineering for female pupils. Their responses include:

> *"bring female students to the workplace and see other females actually working in the role"; "gender specific forums"; "more emphasis in promotional literature and presentation on the creative side of engineering"; "organise relevant work experience"; "sponsorship of initiatives to improve science in schools and to taste engineering subjects"; "visits to firms"; "simplification of engineering material".*

Guidance counsellors were asked to comment on any other actions by **third-level institutes** they felt appropriate to promote engineering for female pupils. Their comments include:

"an Engineering Roadshow for Junior cycle students and a taster course for fifth year students"; "offer career options, clear job descriptions"; "opportunities to view practical applications of engineering projects"; "past pupils and personnel visiting the school"; "talk by third level students more effective than those given by academia"; "the need to simplify information"; "work shadowing for a day – brilliant!".

The following comments were made about promotional materials:

"large colourful posters on notice boards are very effective – pamphlets are not"; "videos are a waste of time and money"; ""Robotics Challenge NUIM".

Specific actions to promote engineering for female pupils by third-level institutes included:

"career talks from engineers (30-35 minutes)"; "specific open days/evenings for female students where they would meet female academics"; "taster courses".

Guidance counsellors were asked to comment on any other actions by **STEPS or IEI** that they felt appropriate to promote engineering for female pupils. Their comments include:

"have a stand at career seminars"; "more emphasis on the student and less on PR"; "specific Roadshows/events for female students – they feel daunted when surrounded by mostly boys (according to students themselves)"; "STEPS failed on each occasion I contacted them to help develop a relationship with an engineering related industry"; "work placements".

4.13 Future Promotional Opportunities

Information was sought in the survey on what various interested parties could do to promote engineering as a career for female pupils.

4.13.1 Parental Role

Guidance counsellors hold the view that parents could inform themselves of the exact job role of engineers; understand the benefits of engineering to the community; and illustrate these benefits to their children.

Typical of the comments are:

"Allow and encourage their children to have an open-mind to non-traditional career paths (but parents must have an open mind too)"; "to have an awareness and understanding of what engineering is all about"; "Attend open days & talks"; "become aware of actual opportunities"; "Give a realistic view of the opportunities available"; "Parenting classes to encourage career awareness from an early age"; "A school-parent-local industry link should be formed'; "Point out concrete examples in the community of engineers, their work and their life-style".

Respondents also believe that parents can view engineering as a non-gender specific career and be informed on the image that they should be portraying engineering as in these comments:

"Avoid the stereotypes of male careers e.g. Engineering"; "Be positive – get rid of gender bias"; become better informed - remove stereotypical image"; become more aware of

opportunities therefore would be less stereotypical and more open"; "by not seeing engineering as a job where a person dirties their hands"; "Encourage students to think beyond traditional female roles"; "I feel the greatest promotion would be to work on getting society away from the gender barriers i.e. HE [Home Economics] for girls and engineering for boys"; "Should talk about careers as non-gender specific". "Encourage girls to at least consider engineering as a career – some parents are very traditional in their advice".

Parents could also encourage their daughters to pursue Higher Level maths and physical sciences:

"Don't view engineering as very maths orientated and too difficult"; "being positive about female students taking honours maths and science"; "better understanding of implications of subject choice by school"; "encourage and aid the uptake/upkeep of honours maths"; "Engineering is seen bound by maths".

4.13.2 Role of Schools

There were numerous suggestions from guidance counsellors about the form of promotional material (including videos, handouts, talks, poster campaign, speaker) that could be issued to schools to encourage more girls to apply for engineering courses:

"brief, clear handouts on the best methods, with some well produced videos – short and specific to each area"; "videos in career classes and good role models at seminars"; "give a good overall view of engineering as a career by promoting it via talks, videos, literature and by encouraging students to do their own research"; "more videos to clarify types of engineering for all students, not just girls"; "poster campaign continuously and videos showing the work"; "resource materials especially for junior students which show females doing now traditional work"; "In order to focus on any 1 career area I must have very interesting, simple, clear presentation and materials, whether it is a speaker, video or literature. All terminology must be layman's language".

Other guidance counsellors referred to subject choice and the need to ensure that girls did not self-exclude by the lack, or perceived lack, of key subjects after the junior cycle:

"Encouraging higher maths, physics and chemistry for junior cycle"; "higher science compulsory up to junior certificate"; "provide technical drawing in girls schools and award engineering/technical prizes for girls only"; "more support for maths particularly"; "Subject choice at 3rd Year, very little effort by schools to accurately relate student ability to relevant subjects. Schools promote 'easy' subjects for school results image to exclusion of Honours Maths, Physics and Chemistry"; "all schools should offer Technical Drawing as a subject"; "better range of subjects".

Some respondents sought a three-way partnership involving schools, universities and industry to promote the idea of getting more girls interested in engineering:

"Bring in past pupils who have become engineers to talk to students"; "good school-industry liaison"; "industry-school partnership and talks by female engineers"; "more visits by professional engineers"; "talks on engineering from the various faculties of engineering"; "STEPS – link with local firms, guest speakers from practising females in the profession"; "constant agenda of having interesting speakers and visits to firms".

Addressing gender specific issues was also raised by respondents and the need to overcome barriers that limit the career choices of female pupils:

> *"gender specific seminars presented by women engineers"; "[Engineering] is perceived as a male industry"; "parents still hold view of engineering as a male career"; "allow female students same subject choice as male students"; "not to see it as a male profession"; "treat engineering as an expected option rather than the unusual for a girl".*

Guidance counsellors also saw a role for themselves and teachers in encouraging girls to take the kind of subject range that would not exclude them from careers in engineering:

> *"treat boys and girls equally in career counselling"; "teachers to have a positive outlook on engineering and females"; "access to guidance counsellors – difficult with present ratio"; "Even girls with Engineering aptitudes – abstract thinking etc., will often think Physics is too hard and go for a leaving subject like Biology and Chemistry. Thus cutting off Engineering etc. Science teachers are the ones who need to be approached about this and they are usually overworked already"; "should be mentioned in subject classes i.e. maths/physics/applied maths so students are aware of possibilities"; "specialist subject teachers need to realise they can promote/turn off students from careers in engineering".*

Finally a small number of respondents felt that the image of engineering needs to be revised and updated to a more accurate reflection on the contribution of the profession and the range of work done:

> *"Present engineering as a valuable career option and as a way of caring for the environment and helping people"; "[engineering] is regarded as an area for brighter students".*

4.13.3 Role of Higher Education Institutions and the Institution of Engineers of Ireland

Guidance counsellors believe that there is a clear role for institutes of higher education (HEIs) and the Institution of Engineering of Ireland (IEI) to provide a clearer explanation as to what each discipline of engineering does and to explain the jargon in simple terms:

> *"Clarification on different aspects of engineering"; "clear job roles, actual destinations of all graduates, not just the best/untypical careers – explain jargon used in course description"; "discuss in an honest way the demands of the (course) profession"; "provide information on how much maths/science are on courses and the standard required"; "different engineering careers to be explained more simply in layman's terms"; "emphasise the human as well as technical side of engineering i.e. the 'beneficial applications' of engineering"; "To have the information to be easily understandable; not to have too much jargon, not to assume that students and teachers understand scientific and Maths terms. To explain the Maths so as not to put students off!"*

Some guidance counsellors saw the potential for a partnership between schools, higher education institutes and parents to promote engineering:

> *"face to face contact between engineer students and kids – engineers to talk about their work [to pupils] before fifth year"; "acknowledge the role of the guidance counsellor. Contact parents associations or local residence associations and give talk to parents in the evening"; "Partnership between institute and schools, firms & schools so students have an opportunity to*

"work shadow" an Engineer, "taster" days at institutes where they get to be an eng. Student for a day/days".

There was also concern voiced by respondents about the need to address gender specific issues, as in 'It's a man's world!' that clearly prevails in the world of engineering:

"be less male orientated in attitude"; "from my students feedback, girls are still regarded as 'lesser' beings than their male counterparts – this is also borne out by the older professors in college"; "promote the image of the profession from its current 'macho' stereotype"; "awareness of and support for equal opportunities – encouragement of girls talented at relevant subjects"; "Language – rather than listing branches of Engineering come up with innovative "warm" words e.g. design. We all know that the word "Engineering" does not turn girls on".

Part of this challenge to gender roles was to promote female role models and/or mentoring for potential female entrants to engineering:

"female role models as speakers"; "provide role models"; "role of female lecturers"; "Need for high profiling of female successful Engineers"; "3rd Level Institutions need to give female students who opt for Engineering a lot more support specifically around Physics/Maths and also mentoring programme".

Guidance counsellors also felt that the education sector and the IEI needed to address the subject choices of girls versus boys and the lack of higher-level maths and a science:

"have pre-engineering and science courses where maths and science are taken in relatively easy steps"; "look at honours maths requirements"; "more flexible entry requirements, especially in relation to maths"; "remove language requirement by NUI colleges"; "make courses accessible to those with good pass maths and science"; "introduce PLC engineering courses – with content worked out by 3rd level colleges. This should enable students to develop suitable levels of maths/physics etc"; "Foundation courses in Engineering".

Guidance counsellors seek promotional materials and were specific about the nature of these in the forms of -

Talks:

"give well thought out, interactive promotional talks in 1st and 2nd year – not 5th or 6th year"; "more proactive in visiting schools – need to talk to Junior Cycle students"; "show them female role models"; "representation/visits by female engineers"; "be prepared to visit schools – it is not easy to go to colleges"; "go to secondary schools to talk and show students practical information"; "Offering female Engineering students as speakers to school, Girls into Engineering Programmes are excellent".

Brochures:

"make literature more meaningful and less technical"; "posters, clear handouts to spearhead the information with more detailed and visual (lots of pictures) pamphlets to follow"; "literature needs to be more student friendly".

Videos/CD:

"Make videos showing different Engineers at work and particularly show engineers in Third World countries helping people with drains, wells etc. students always want the human factor. To most girls engineering is all about things not people"; "Produce a down to earth practical video – engineers at work/ college courses with solid information some videos have too much emphasis on presentation, music etc and little content"; "provide clear, interesting cameos on CD – profiles on young, dynamic, successful women engineers".

Visits to HEI Engineering departments:

"open days should be promoted"; "organise open days in engineering facilities – put on summer/holiday engineering programmes"; "workshops given in college"; "seminars for guidance counsellors and teachers"; "open days/exhibitions/fairs"; "arrange hands-on/half days at colleges. Arrange mentoring/work shadowing possibilities for students in workplace".

STEPS/IEI Events:

"IEI could hold seminars at night or on the weekends in regional areas – Dublin based events are 6 hour round trip for students"; "make STEPS more school based as talks, visits, small presentations are much easier to organise within the school".

Successful Material/Promotion:

"NOW programme re-introduced"; "STEPS is a good initiative and is well run"; "Prof. Byrne's book is excellent!"; "The Engineering Open Days at I.T's are very successful and explanatory. We travelled to LIT and students gained a lot of information on specific disciplines"; "IUP as in UL (STEPS)"; "A.I.T are promoting women in Engineering at present"; "Continuing with their present programmes of "Women in Engineering and Technology""; "Workshops – the DCU workshops had a huge influence on the girls in our school"; "video produced by Forfas".

4.13.4 Role of the State and Department of Education

Guidance counsellors sought improvements to lab and equipment facilities in schools:

"Better facilities for science subjects and for ICT and Computers in schools"; "Ensure that teacher/ facilities in Maths/ Physics areas are available in girls schools"; "Give equipment and proper facilities to schools"; "By funding Science labs and Engineering, Technical Drawing, workrooms in schools etc."; "More lab facilities"; "Provide finance for Science subjects e.g. equipment".

Other respondents sought changes in subject availability and/or revision of the curriculum:

"Either drop Irish or continental languages as essential for entry to NUI Colleges"; "Introduce Engineering or construction as a compulsory subject for girls. Many females don't pursue Engineering because they feel they will be the only girls in the class"; "More resources to teach Science and Maths in an experimental / problem solving way"; "Revision of heavy Cert. exam, moving to modular/ continuous assessment methods"; "Revise Junior Cert. science syllabus so that students are not turned off science by the time they do the Junior Cert."; "Change Science courses more practical lab based"; "Perhaps introduce an Engineering element to the Science courses?"; "Make Science/ Maths more user-friendly and make it easier to achieve good grades

in Physics/ Chemistry. The image and reality is that these subjects are difficult for very many students"; "Very often Applied Maths, for example, is taught in girls schools outside the timetable and demands funding for same and because of limited resources this puts huge pressure on school; for example Technical Drawing is not available in most girls schools".

Media coverage was mentioned as playing a key role in making engineering an area of study with wider appeal:

"T.V. ads – make it look exciting and attainable"; "Advertising/ make it attractive. Media especially, television billboards"; "Fund/ promote a soap opera that has a character who works as an engineer and show him/her at work; like they already show doctors, nurses, lawyers, bar workers, farmers, police, priest etc."; "Give money to RTE to invent a soap opera with Engineers in main roles"; "Higher profile i.e. advertising campaign, etc"

Some sought the intervention of the Department of Education and Science to improve the role, responsibility of, and supports for, guidance counsellors in schools:

"Provide GCs at a realistic ratio to enable students to get the support they need in their career research and academic decision making"; "Reduce the ratio of GCs: students to 1:250 a.s.a.p."; "Guidance Counselling available in all schools"; "Permission to attend relevant seminars by interested students – difficult with the Minister "ban" and teachers attending seminars/ bringing students to such events"; "Open Days/ visits to factories/ STEPS Road Show. Recognised by the dept. as in service, i.e. Provision of sub or allowance for school to cover teacher's absence".

"Fund guidance counsellors (mileage) to go to conferences top obtain more information"; "Fund scholarships for those wishing to pursue a career in Engineering"; "Need Research Institute in Science, Engineering, technology, promote its status at National level"; "For schools to take part in the STEPS programme buses need to be hired etc. schools don't have the money and guidance counsellors are trying to collect money, a desperate waste of a guidance counsellors time"; "More resources for schools in terms of improved pupil/teacher ratio"; "Resources for schools to employ teachers of science etc.".

Promotional material was raised with the view that the government department should be involved:

"Engineering/woodwork; talks in girls' school"; "Organize speakers for schools from industry or colleges"; "Produce "female" friendly outlook in relation to Engineering."; "Produce more videos – kids wont read brochures until they're in 5th or 6th Year".

4.14 Conclusions

- Girls choose engineering because of the 'academic ability/intellectual challenge' while boys choose it because of the 'earning potential'. Girls also perceive a lack of female 'role models'.
- The role of father is seen to be the most influential to both male and female pupils' career decisions while maths and science teachers also exert a strong influence.
- The majority of guidance counsellors feel that 'common entry' into engineering is a better option for all pupils.

- Schools have very little direct contact from engineering firms yet higher education institutions and STEPS had contacted 4 out of 5 guidance counsellors. Respondents felt the need for specific actions to be adopted by industry, higher education institutions and engineering initiatives in order to interest female pupils in engineering. Specific actions include:
  - Having school talks about engineering by women engineers from industry, women engineering students and women engineering lecturers;
  - Establishing a mentorship system between female pupils, industry, higher education institutes and engineering initiatives;
  - Describing profiles of women engineers, which allow pupils to learn what an engineer does.
- Guidance counsellors believe parents could inform themselves of the exact job role of engineers; understand the benefit of engineering to the community; and illustrate this benefit to their children. They would like parents to view engineering as a non-gender specific career; be informed on the image they should be portraying; and encourage their daughters to pursue higher-level maths and physical sciences.
- The promotional materials issued to schools to encourage more girls to consider engineering include videos, handouts, poster campaigns and visits by speakers to schools. Guidance counsellors believe that a three-way partnership between schools, higher education institutions and industry would be effective in encouraging female pupils. They suggest the introduction of 'gender specific' seminars for female pupils and felt that all teachers need to demonstrate positive attitudes to engineering during science class and careers class. They also feel that0 higher education institutions should provide clear explanations as to what each discipline of engineering does, by explaining in laypersons' terms.
- Guidance counsellors specifically seek the following:
  - Improved ratio of guidance counsellors to pupils;
  - Access by pupils to talks and presentations;
  - All school subjects open to female pupils;
  - Awareness and support for equal opportunities;
  - Promotion of role models (e.g. past pupils);
  - Speakers from/visits to firms;
  - Use of aptitude tests early on to identify aptitudinals;
  - Encouragement for girls to study higher-level maths and physics.

5. Survey of Secondary School Pupils

5. 1 Introduction

Much of the literature surrounding career choices for female pupils is based on girls entering Science, Engineering and Technology (SET). Within this SET context, a high proportion of research is based around female students who are already participating in third-level engineering. There is a lack of formal, national research in Ireland investigating female pupils' attitudes to engineering. This study aims to remedy this gap by conducting a national survey, targeted at Leaving Certificate students and querying their views on engineering.

5.1.1 Background to the Survey

CAO System

The objective of this survey was to investigate the factors that encourage and discourage female pupils from entering engineering at Higher Education Institutes. Secondary schools pupils access information about careers from many different sources. These include their parents, siblings, relatives, peers, teachers, guidance counsellors and the media.

The Central Admission Office (CAO) facilitates applications for engineering and other undergraduate higher education in the Republic of Ireland. Universities and Institutes of Technology participate in the CAO system but retain full control over their individual admission policies and decisions. This includes a subject or grade pre-requisite. Most institutions with engineering courses have a policy that a pupil must earn a Higher C grade in Maths in order to be accepted into engineering.

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A pupil filling in their CAO form can choose up to ten Degree options and an additional ten Diploma options at third-level institutions. They will have already chosen which CAO courses they want to pursue prior to sitting the Leaving Certificate examination (Central 2004)

5.1.2 Survey Objectives

A survey of final year Leaving Certificate pupils attending post-primary schools was undertaken to ascertain:

- subject choice in Leaving Certificate examination;
- knowledge of subjects that are a pre-requisite to studying engineering;
- if they have applied to engineering courses through the CAO system and why;
- understanding of the role of an engineer;
- perceptions of the personal characteristics and skills of an engineer;
- the technical competence/experiences of pupils;
- who the key influencers are in career decisions;
- usefulness or otherwise of information on engineering.

5.1.3 Survey Methodology

The sampling frame was decided as all final year pupils in secondary schools sitting the Leaving Certificate examination in June 2004. This was chosen because a pupil wishing to continue to third-level would have completed their CAO application form in January 2004.

Once designed, the questionnaire was piloted at an all-girls secondary school in Dublin. The pupils commented on the questions and the flow of the questionnaire and consequent changes were made.

The post-primary schools were selected by modelling the sampling methodology from 'Schooling and Sex Roles: Sex differences in Subject provision and student choice in Irish post-primary schools' (Hannan 1983).'. A probability sampling method was used with each school having equal chance of being selected from the sampling frame. The sampling frame was a list of all post-primary schools registered with the Department of Education and Science in 2002. The simple random stratified sampling method used location, type and gender make-up of school as strata. Stratified sampling allows the sample to be representative of all schools in Ireland. Schools were chosen as the primary sampling unit with pupils within schools being the secondary unit.

Table 5.1 shows the schools sampling and response rates while Table 5.2 outlines the pupil sample and response rate, each at the one-strata level of type of school. The overall response rate of 47 per cent of schools selected was exceeded in secondary schools (55%) and community/comprehensive schools (55%); and lower in vocational schools (32%).

Table 5.1 School Sample Characteristics

	No. of Schools Sampling Frame	Schools Sampled	Schools Response	% Response
Secondary	410	51	28	55%
Vocational	247	31	10	32%
Community/Comprehensive	89	11	6	55%
Total	**746**	**93**	**44**	**47%**

A self-administered postal survey was chosen over other methods such as interview-based surveys or Internet surveys. The postal survey can reach a wider range of schools and a larger number of pupils at a national level.

A hand-signed letter on headed notepaper, with an enclosed 'acceptance slip', was sent to the 93 principals of the schools selected. The letter explained the details of the project and requested permission for the schools to participate. The acceptance slip, signed by the principal indicating that the school would participate, was to be returned FREEPOST to the Department of Industrial Studies, Trinity College, Dublin. Follow up phone calls to the principals were made, two weeks after the original letter was sent out. The aim of the calls was to discuss the project and arrange the logistics of the questionnaires being administered in the schools.

A detailed questionnaire was sent out in April 2004 to 2,571 Leaving Certificate pupils in 55 post-primary schools that agreed to take part in the survey. A batch of questionnaires was sent to each school to be administered during the week of April 19th – April 24th 2004. The batch included a letter of administration (Appendix E), questionnaires (Appendix F), envelopes to put questionnaire in once completed (to protect anonymity and confidentiality) and FREEPOST envelopes for the administrators to send completed questionnaires to the Department of Industrial Studies, Trinity College, Dublin.

A total of 1,813 pupils responded to the questionnaire. The total response rate is 70 per cent by pupils. Two per cent of pupils (64 respondents) could not be accounted for by school which explains the disparity between actual response rate (70 per cent) and response rate by school type (68 per cent). Table 5.2 shows the pupil response rate from different types of schools. The response rate was 68 per cent from secondary schools; 87 per cent responding from vocational and 57 per cent from community/comprehensive schools.

Table 5.2 Pupil Sample Characteristics

	Pupils Sampled	Pupils Response	% Response
Secondary	1830	1246	68%
Vocational	270	234	87%
Community/Comprehensive	471	269	57%
Total	**2571**	**1749**	**68%**

The questionnaire included questions of a closed nature (Yes/No or scale) AND open-ended questions to allow respondents to provide their views in more detail. This chapter deals mainly with the quantitative responses to the questionnaire.

5.2 Profile of Schools Surveyed

This Section sets out the profile of location of the school they attend, type of school they attend, and gender composition of their school.

5.2.1 Location of School

Information was sought on where respondents attend school. The results show that half of the respondents attend schools in Leinster (50%), then Munster region (31%), followed by schools Connaught (14%). Five per cent of male and female pupils attend schools in Ulster (Table 5.3).

Table 5.3 Location of School

	Male	% Male	Female	% Female	Total	% Total
Leinster	336	47%	533	52%	869	50%
Munster	226	32%	304	30%	530	31%
Connaught	100	14%	149	15%	249	14%
Ulster	47	7%	41	4%	88	5%
Total	**709**	**100%**	**1027**	**100%**	**1736**	**100%**

5.2.2 Gender Composition of School

Nearly three-fifths of the respondents attend a co-educational school (58%) while one-third (33%) per cent attend an all-girls school. The remaining 9 per cent of the respondents attend an all-boys school (Table 5.4). A lower response rate from all-boys' school is not surprising given the nature of the research topic.

Table 5.4 Gender composition of School

	Male	% Male	Female	% Female	Total	% Total
Co-Educational	552	78%	447	44%	999	58%
All Girls	0	0%	580	56%	580	33%
All Boys	157	22%	0	0%	157	9%
Total	**709**	**100%**	**1027**	**100%**	**1736**	**100%**

5.2.3 Type of School

Information was sought on the type of school Leaving Certificate pupils attend. The results show that more than two-thirds of the respondents (67%) attend secondary schools, while one quarter (25%) attends community/comprehensive schools and less than ten per cent (8%) of pupils attend vocational schools (Table 5.5).

Table 5.5 Type of School

	Male	% Male	Female	% Female	Total	% Total
Secondary	380	54%	789	77%	1169	67%
Community/Comprehensive	252	36%	182	18%	434	25%
Vocational	76	10%	56	5%	132	8%
Total	**708**	**100%**	**1027**	**100%**	**1735**	**100%**

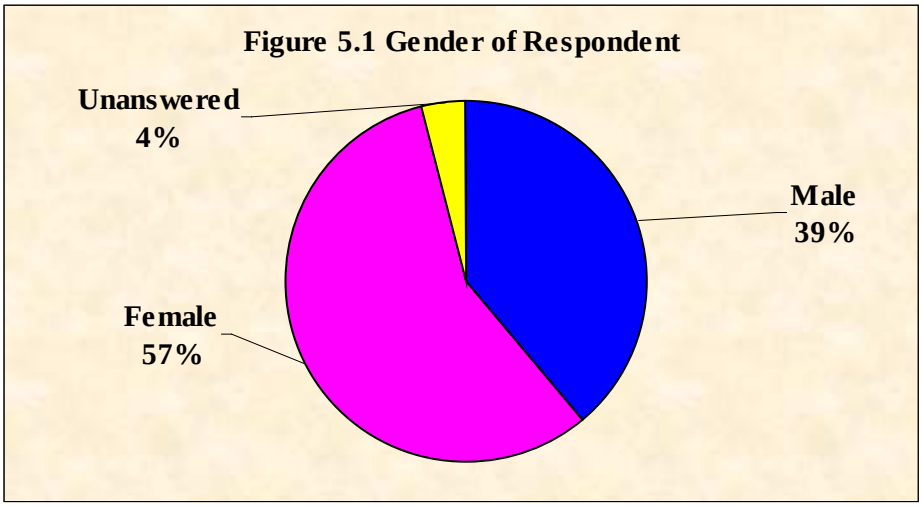
The majority of pupils who responded to the questionnaire attended non-fee paying schools (86%) with 14 per cent attending fee-paying schools. .

5.3 Profile of Pupils in Schools Surveyed

The survey data are based on the responses of 1,813 Leaving Certificate pupils. The remainder of this chapter provides an analysis of questionnaire data collected, according to gender of respondent.

5.3.1 Gender of Respondents

The 1813 responses to the questionnaire included 709 male (39% of total) and 1027 female (57% of total) pupils. An additional 77 respondents (4%) did not state their gender (Figure 5.1).

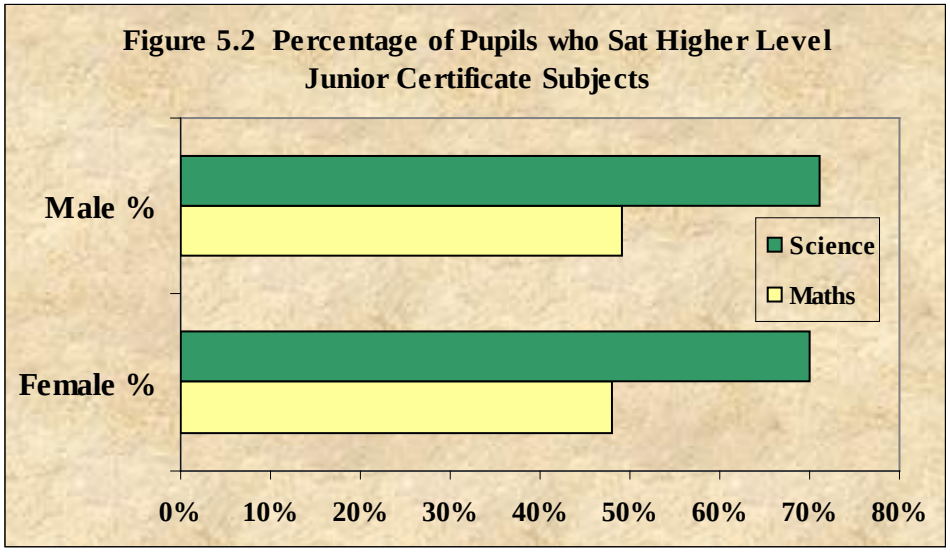


The study sought to establish whether female pupils *do* have the necessary academic requirements to study engineering at third-level. The main subject and grade required by most engineering courses at third-level is a C grade earned at Higher Level maths Leaving Certificate examination. If a pupil does not have this requirement, they cannot study engineering at degree level.

5.3.2 Junior Certificate Subject Taken

It might be anticipated that a pupil who studied Higher Level maths at Junior Certificate examination, is more likely to study maths at Higher Level for their Leaving Certificate. Less than half of the respondents (48%) sat the Junior Certificate examination in Honours Level maths.

Conversely, if a pupil has not sat the Higher Level Junior Certificate maths, they would not be able to study the Honours Leaving Certificate maths course. Figure 5.2 indicates that similar proportions of male pupils (49%) and female pupils (48%) have the academic preparation to study Higher Level Leaving Certificate maths examination. There are no statistically significant differences between female and male pupils who took Higher Level Junior Certificate maths.



At Junior Certificate Higher Level Science, 70 per cent of female pupils and 71 per cent of male pupils sat this exam. Differences between gender and pupil studying Higher Level Junior Certificate science are not significant.

5.3.3 Leaving Certificate Subjects Taken

Higher Level maths is a pre-requisite to study engineering at most Higher Education Institutions. Among respondents, more than one-quarter (28 %) of male pupils but less than one-fifth (19%) of female pupils are studying Higher Level maths for the Leaving Certificate, indicating that only these pupils are academically eligible to study engineering.

A high proportion of male (72%) and female (81%) pupils are studying Ordinary Level maths for the Leaving Certificate. Differences between gender and the level at which a pupil is studying Leaving Certificate maths were statistically highly significant. Pupils used to get extra points for studying higher-level maths. It was seen as a very difficult subject for pupils to be awarded good grades. The amount of work required to do well in this subject was helped by the extra points earned. Pupils still see maths as a 'difficult' subject. This may explain the very low uptake of Higher Level maths for the Leaving Certificate.

Figure 5.3 shows that biology is the most popular of the sciences at Higher Level, taken by half of all female respondents and 27 per cent male pupils. The second most popular science choice for female pupils is chemistry (17%). For male pupils at Higher Level the most second most popular subject is physics with 24 per cent studying this yet only 8 per cent of all female respondents are studying higher-level physics. The lowest uptake is applied maths with only four per cent of all pupils studying this subject.

Figure 5.3 Percentage of Pupils who are Studying Higher Level Leaving Certificate Subjects

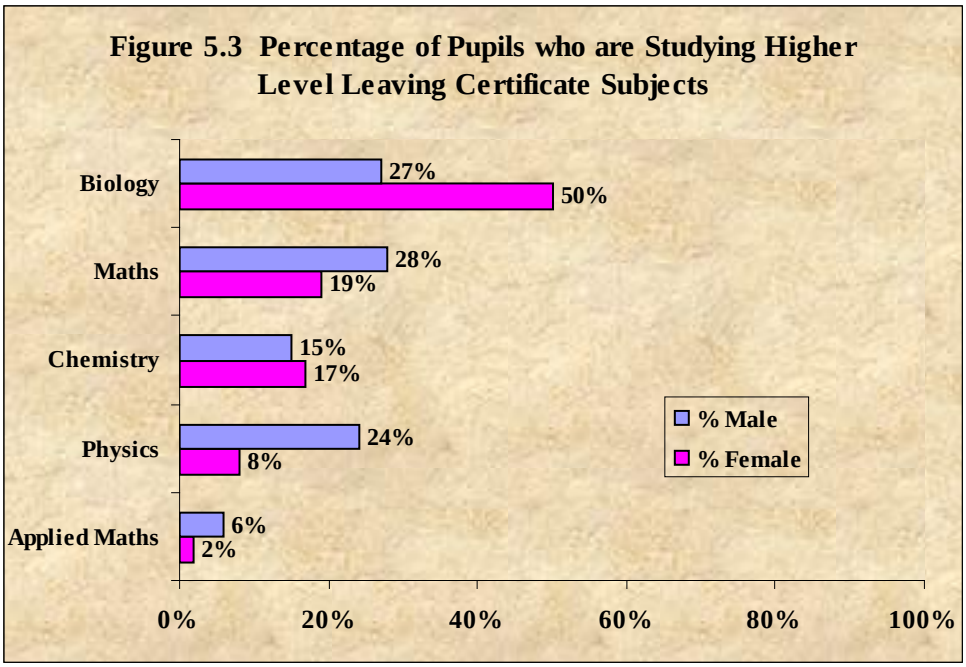
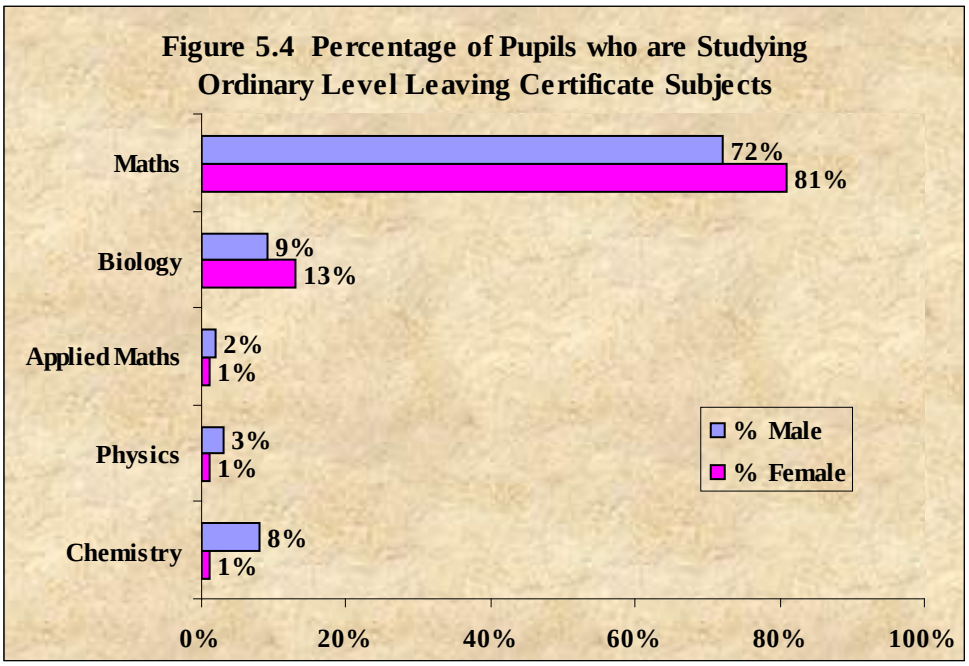


Figure 5.4 highlights the low number proportion of pupils studying physical sciences at Ordinary Level for the Leaving Certificate. Nine per cent of male pupils and 13 per cent of female pupils are

studying Ordinary biology for the Leaving Certificate. For all male and female pupils, less than 5 per cent are studying physics, chemistry or applied maths.



5.3.4 Subject Pre-requisite for studying Engineering at Third-Level

Pupils were asked to what Leaving Certificate subjects are needed to study engineering at third-level. Table 5.6 illustrates that the first subject needed by pupils to study engineering, mentioned by 78 per cent of pupils, was maths, followed by physics (15%) and engineering (7%). Significantly more male pupils consider engineering to be a vital subject to continue with engineering at third-level.

Table 5.6 Subjects needed for the Leaving Certificate to Study Engineering at Third-Level

	Male	% Male	Female	% Female	Total	% Total
Maths	445	75%	698	80%	1143	78%
Physics	84	14%	133	15%	217	15%
Engineering	65	11%	37	4%	102	7%
Total	**594**	**100%**	**868**	**100%**	**1462**	**100%**

Chi-Square P =0.000

5.4 Engineering as a Career Choice

5.4.1 CAO Applications

Sixty eight per cent of male pupils and 79 per cent of female pupils surveyed have applied to the CAO system. In total, just under a quarter of all pupils (74%) have applied to the CAO. Over one-quarter of male respondents (28%) and just less than one-fifth of female respondents (18%) have not applied (Table 5.7). The differences between gender of a pupil and whether they have applied to the CAO system are statistically highly significant.

Table 5.7 Applied to CAO

	Male	% Male	Female	% Female	Total	% Total
Yes	481	71%	809	82%	1290	77%
No	195	29%	183	18%	378	23%
Total	**676**	**100%**	**992**	**100%**	**1668**	**100%**

Chi-Square P =0.000

5.4.2 Engineering as a CAO option

When asked whether they had considered applying for a CAO engineering course only 81 per cent of pupils responded. Among those who responded, male pupils were statistically significantly more likely than female pupils to have considered engineering as a CAO option. Half of the male pupils who responded to this question stated that they have considered engineering while only one out of every ten female pupils who responded to this question has thought of engineering. Overall, one-quarter (26%) of pupils surveyed considered engineering as a course of study (Table 5.8).

Table 5.8 Considered Engineering as a CAO option

	Male	% Male	Female	% Female	Total	% Total
Yes	273	50%	88	10%	361	26%
No	276	50%	766	90%	1042	74%
Total	**549**	**100%**	**854**	**100%**	**1403**	**100%**

Chi-Square P =0.000

Respondents were asked to comment on why they might have considered engineering to be the right career choice for them or otherwise. The responses follow in Section 5.4.3.

5.4.3 Reasons for *Not* Choosing Engineering - Male pupils

There were only three main reasons why male pupils did not consider engineering. Either they were not studying the correct subjects for engineering or they had no interest in engineering or thought that they were better at other subjects/areas.

a) Better at other subjects:

> *"better at language and writing"; "Don't like manual labour. Not into science subjects and I'd rather humanity/social subjects"; "prefer theoretical side of physics"; "want to be an accountant"; "want to be a solicitor*".

b) Not having the pre-requisite subjects/Maths:

> *"Didn't do it for the leaving cert"; "Do not do honours maths"; "have never taken an engineering class"; "not doing higher maths and think it would be difficult to study"; "subject choices did not suit"; "Maths is too time consuming and I am weak at it".*

c) No interest or lack of knowledge:

"Don't know what engineering is about"; *"never considered it as I never understood what it involved"; "no interest"; "no interest in metalwork and no good with my hands"; "seems boring".*

5.4.4 Reasons for *Not* Choosing Engineering - Female pupils

Girls had more varied reasons as to why they never considered engineering as the right career for them.

a) Non-Traditional Career/'Only for Males':

"A male career and therefore not interested"; "Always thought of it as a practical subject aimed towards the male population"; "hard to find a job and harder for a female"; "feel it is a very male orientated course"; "male dominated course and wouldn't feel accepted as a female engineer"; "more a male job"; "never considered it as it is usually males that do engineering"; "not interested but as a female feel intimidated"; "only for males".

b) Better at Other Subjects:

"Bad at maths and art"; "like working with children"; "prefer science and am not good at maths"; "more interested in teaching or psychology"; "more interested in business"; ""want to do nursing or science"; "prefer arts and classics"; "prefer science subjects".

c) Lack of Career Advice/'Never Explained about Engineering':

"Career guidance teacher never told me about it and I know nothing about it"; "Don't know what it involves as it was never explained to us"; "never told about engineering so did not consider it but now I have the knowledge of the course, it looks very interesting"; "not given correct guidance to keep on science"; "not enough information supplied for females".

d) Not having the Pre-requisite Subjects/Maths:

"Considered it but leaving cert subjects would not enable me to apply for this course"; "Do not do higher maths/physics"; "Do not study honours maths therefore I am discriminated against a career in engineering"; "don't do honours maths otherwise I would be interested"; "not mathematically minded".

e) 'Don't' know much about Engineering'/Lack of interest due to lack of Knowledge:

"No interest but don't know anything about it"; "no interest and was not informed about the courses"; "no interest and points very high". "Do not have option of studying metal or wood work so don't know if I am suited to it"; "Doesn't interest me because I don't know much about it"; "Don't know about it, think it would be boring"; "Don't know what engineering is so don't know if it appeals or not"; "Don't know what is required"; "Don't know what is

involved and what you would do at the end of the course"; "Not certain what it involves, the career is not very obvious to me"; "you need high points".

f) Difficult Profession

"science subjects are harder than others"; "too difficult"; "not paid enough, job too hard and don't like physical work"; "not very good at making things"; "seems to be a hard and complicated job"; "too hard"; "very difficult subjects";

Many of the female pupils mentioned primarily that they had no interest in engineering or the profession but often followed it with a statement such as they 'didn't know much about engineering anyway'.

5.4.5 Applied for Engineering

Respondents were then asked if they applied for any engineering courses through the CAO system. Nearly one-third of all male respondents (31%) applied to an engineering course while less than five per cent of all female respondents applied to engineering though the CAO system. Gender differences in applying for engineering courses are highly statistically significant. Men are more likely than women to apply to engineering courses. In total, 15 per cent of all pupils had applied to an engineering course (Table 5.9).

Table 5.9 Applied to Engineering through CAO

	Male	% Male	Female	% Female	Total	% Total
Yes	221	31%	38	4%	259	15%
No	46	6%	57	6%	103	6%
Non Response	442	62%	932	91%	1374	79%
Total	**709**	**100%**	**1027**	**100%**	**1736**	**100%**

Chi-Square P =0.000

Pupils were asked whether they would accept a place in an engineering course if offered through the CAO system. Over one-fifth of all male pupils (27%) will accept a place in an engineering course if offered while only 3 per cent of all female pupils will accept a place in an engineering course. The gender differences in accepting a place in engineering if offered are statistically highly significant.

Table 5.10 Would Accept Engineering Course if Offered

	Male	% Male	Female	% Female	Total	% Total
Yes	189	27%	33	3%	222	13%
No	49	7%	25	2%	74	4%
Non Response	471	66%	969	94%	1440	83%
Total	**709**	**100%**	**1027**	**100%**	**1736**	**100%**

Chi-Square P =0.000

5.4.6 Reasons for Accepting Engineering if Offered by CAO- Male Pupils

a. Interesting field to study:

"For my interest in how things work"; "Interest in multimedia"; "Feel I am suited to the course"; "Like the practical work"; "not interested in anything else"; "There is a vast area which surrounds engineering"; "worked on road building etc. during holidays and wanted to get qualified so I could get a good job doing what I liked"; "would like to do construction engineering as it is exciting".

b. Career Prospects:

"A challenging career"; "there will always be a need for engineers"; "has high salaries"; "being able to travel and work abroad"; "has a wide field from civil to mechanical so there are plenty of jobs, well paid"; "lots of good jobs available"; "widen my life options".

c. Maths and Problem-Solving Interest:

"A logical, easy subject"; "Enjoy maths"; "Enjoy the idea of problem-solving and do not like the idea of a monotonous job"; "enjoy working with electronics/machines and problem-solving"; "like maths, physics and chemistry".

5.4.7 Reasons for Accepting Engineering if Offered by CAO- Female Pupils:

"Find it interesting and did it for my work experience"; "Interested in designing things"; "I like to try something different"; "Maths is interesting and I think I would like the work although I don't do physics"; "Good pay and very challenging"; "Good money".

There were very few positive comments about why female pupils would choose engineering. Male pupils tended to have a greater range of reasons as to why they would pick engineering.

5.4.8 Degree Preferences for Engineering

Pupils were asked to state which preferences they allocated to engineering on their CAO application form. Thirty-seven per cent of male pupils selected engineering as their first, second or third degree option while only three per cent of female pupils did so (Table 5.11).

Percentage values in Table 5.11 do not add to 100 per cent because the CAO application system allows an applicant to have ten choices for Degree or Diploma. For example, a pupil could choose to apply to ten different engineering degree courses and ten engineering diploma courses.

Table 5.11 Degree Course Preference

Preference	Male	% Male	Female	% Female	Total	% Total
First	90	13%	11	1%	101	6%
Second	85	12%	9	1%	94	5%
Third	88	12%	11	1%	99	6%
Fourth	70	10%	6	1%	76	4%
Fifth	44	6%	6	1%	51	3%
Sixth	24	3%	6	1%	30	2%
Seventh	18	3%	3	<1%	21	1%
Eighth	16	2%	4	<1%	20	1%
Ninth	18	3%	3	<1%	21	1%
Tenth	13	2%	2	<1%	15	1%

5.4.9 Diploma Course Preferences

Pupils were asked to state which preferences they allocated to engineering on their CAO application form. Thirty per cent of male pupils selected engineering as their first, second or third diploma option while only three per cent of female pupils did so (Table 5.12).

Table 5.12 Diploma Course Preference

Preference	Male	% Male	Female	% Female	Total	% Total
First	85	12%	7	1%	92	5%
Second	67	9%	6	1%	73	4%
Third	66	9%	10	1%	76	4%
Fourth	40	6%	5	<1%	45	3%
Fifth	22	3%	5	<1%	27	2%
Sixth	19	3%	2	<1%	21	1%
Seventh	20	3%	1	<1%	21	1%
Eighth	18	3%	2	<1%	20	1%
Ninth	13	2%	1	<1%	14	1%
Tenth	16	2%	2	<1%	18	1%

Percentage values in Table 5.12 do not add to 100 per cent because the CAO application system allows an applicant to have ten choices for Degree or Diploma

5.5 Key Influences to Study Engineering

Respondents were asked who might influence them to study engineering.

5.5.1 Family Members who Studied Engineering

Pupils were asked if any members of their immediate family had studied engineering. In total, 12 per cent of all pupils had a brother who studied engineering while one in ten pupils had a father who was an engineer. Only three per cent of all pupils had a sister with an engineering background while one per cent of respondents had a mother with an engineering background (Table 5.13).

Table 5.13 Family members who studied Engineering (male n = 709, female n = 1027)

	Male	% Male	Female	% Female	Total	% Total
Brother	96	14%	105	10%	201	12%
Father	76	11%	93	9%	169	10%
Sister	27	4%	21	2%	48	3%
Mother	13	2%	9	1%	22	1%

Percentage values do not add to 100 per cent because all members of the family may study engineering.

5.5.2 Key Career Influences

Pupils were asked to comment on how important they found certain people in helping them with their career decisions. Significantly more female pupils responded by indicating that their mother (36%) is very important in helping them with their career decisions compared with one-quarter (25%) of male pupils. One-quarter of pupils, both male and female, consider the father to hold a very important role in career decision-making. Guidance counsellors are also considered to be very important with one in every five pupils finding them to be very important. Significantly more female pupils (59%) consider their friends to play a role in helping a pupil decide their career path compared with male pupils (44%). Maths and science teachers, school principals, older brothers and sisters are considered not important in career decision-making.

5.5.3 Encouraged to Study Engineering

The survey sought to identify the key persons who would have influenced them to consider studying engineering as a CAO option (Figure 5.5).

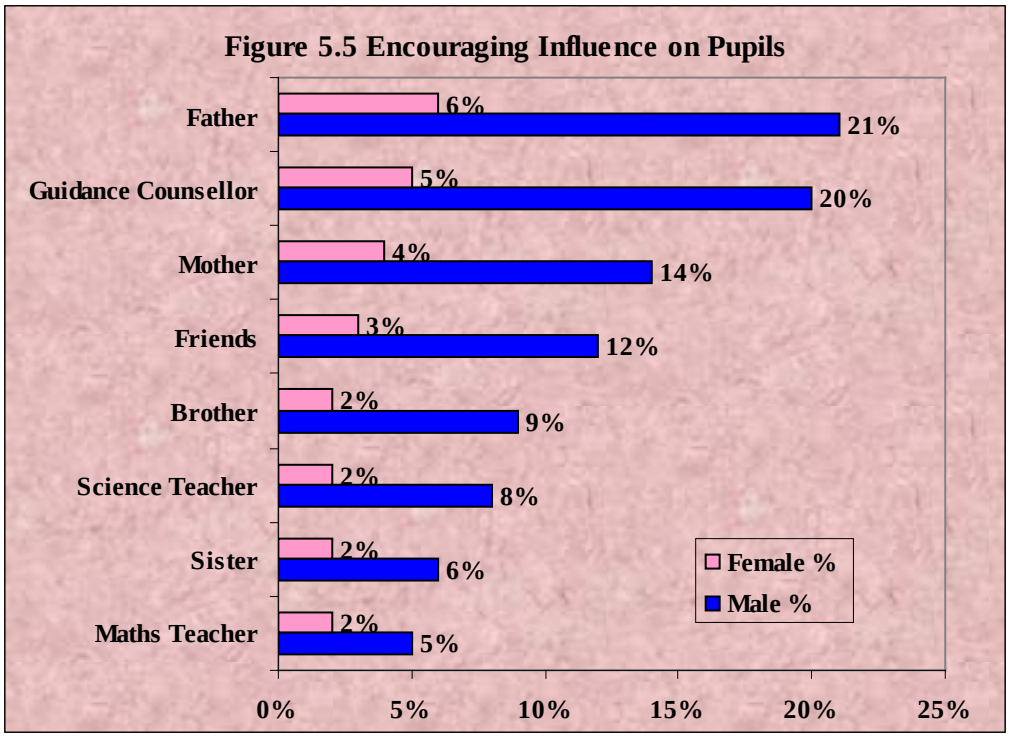
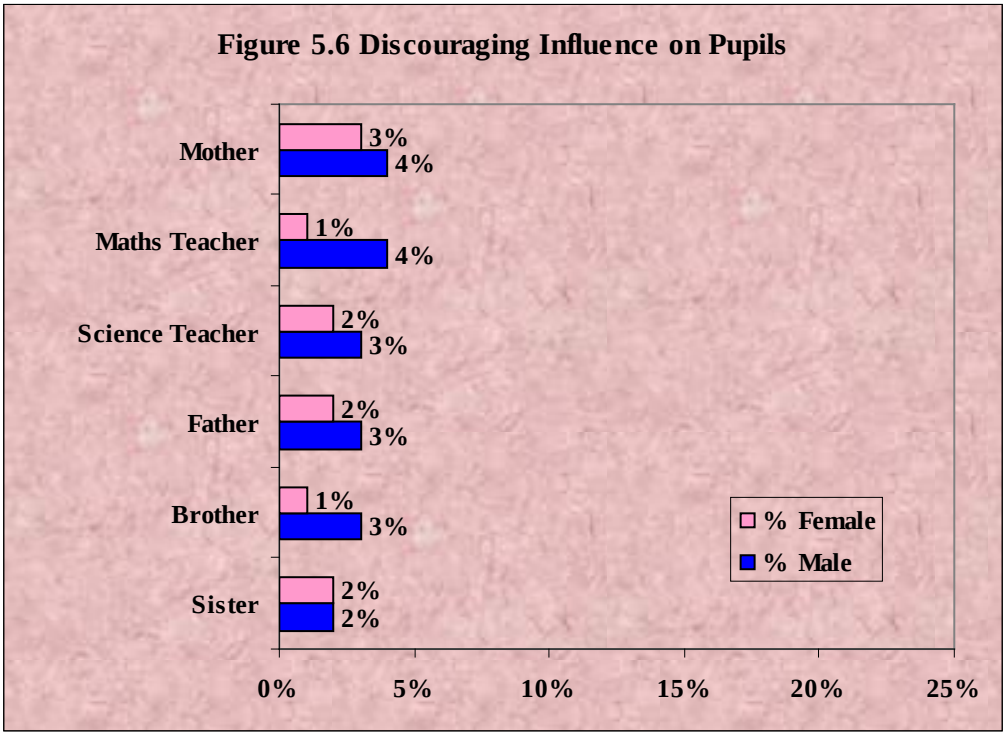


Figure 5.5 shows that for male and female pupils, fathers are deemed the most influential (21% and 6% respectively) and guidance counsellors the second most important influence (20% and 5% respectively). Male pupils consider their maths teacher to be the least important influencer (5%) in encouraging them to study engineering. The responses are low by female pupils to this question because only a small minority had considered engineering as a CAO option.

5.5.4 Discouraged from Studying Engineering

Figure 5.6 highlights the individuals that male and female pupils found to be the most discouraging influence from studying engineering at third-level. The most discouraging influence for male pupils considering engineering as a CAO option is their guidance counsellor (7%) followed by friends (5%). The percentages are considerably lower than encouraging influences. For female pupils, the most discouraging influence is the guidance counsellor (4%) followed by friends (3%) and mother (3%).

Figure 5.6 Discouraging Influence on Pupils

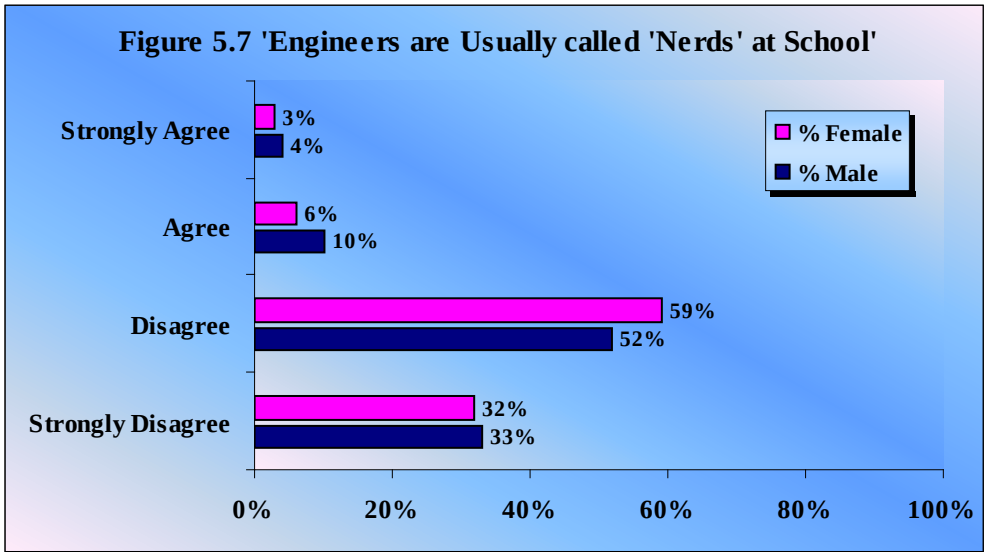


5.6 Beliefs about Engineering

Information was sought in the questionnaire on pupils' perceptions and beliefs about engineers and engineering, using a range of attitudinal statements testing respondents' level of agreement or disagreement with each statement on a four point Likert Scale.

5.6.1 Image of Engineering Courses/Study

Differences between gender and the opinion that 'engineers are usually called nerds at school' are statistically significant. The majority of pupils disagree/strongly disagree that engineers are called 'nerds' at school. Eighty-five per cent of male pupils and 78 per cent of female pupils do not think engineers are considered 'nerds' at school (Figure 5.7).



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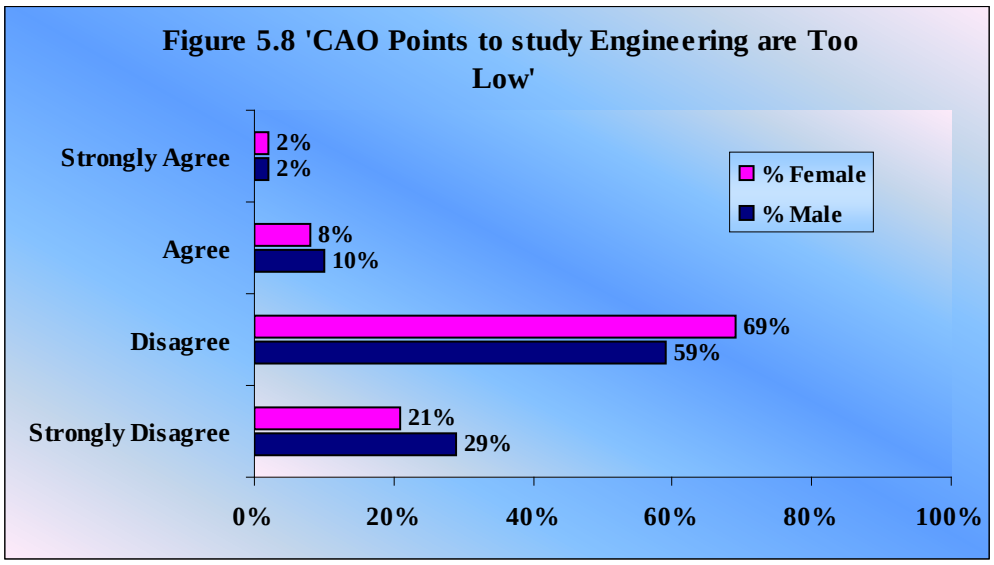
'CAO points to study Engineering are too low'

The majority of pupils do not believe that the CAO points for engineering are too low. More males (29 per cent) strongly disagree compared with 21 per cent of female pupils that the points are too low (Figure 5.8). Differences between gender of pupil and their views on whether the CAO points are too low are significant.



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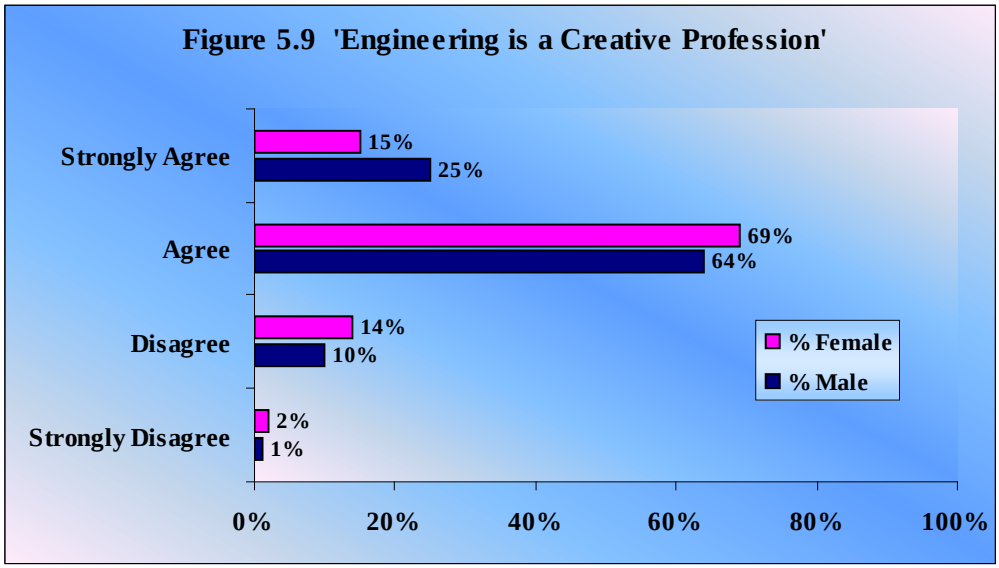
Pupils were asked whether they agree with the statement that 'Engineering is a Creative Profession'. One-quarter (25%) of male respondents and 15 per cent of female pupils agreed strongly that engineering is a creative profession. In total, 84 per cent of female pupils and 89 per cent of male pupils agreed/strongly agreed with the statement (Figure 5.9).



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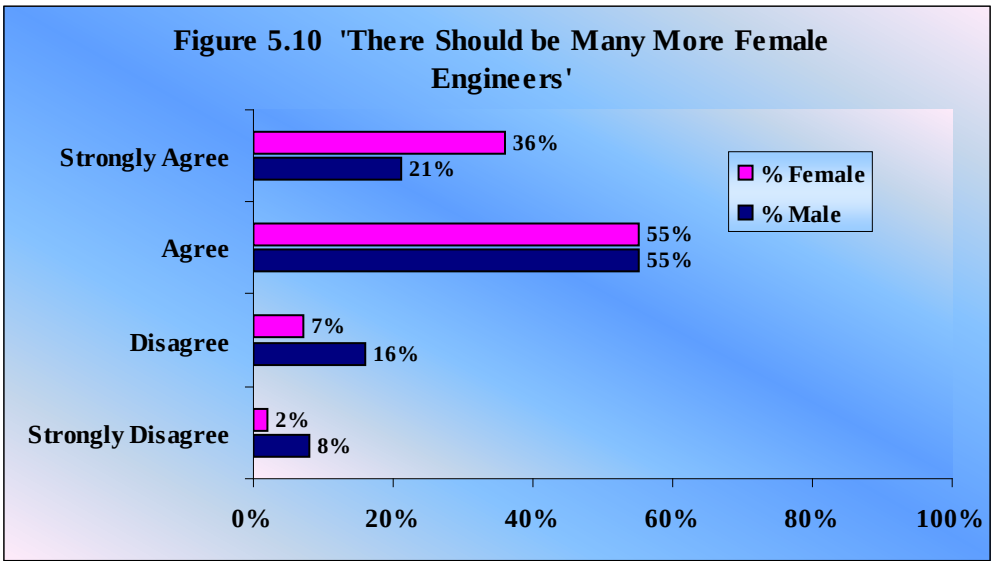
5.6.2 Gender Issues within Engineering

'There should be more Female Engineers'

Differences between gender and the statement 'there should be more female engineers' are statistically highly significant. Many more female pupils (36%) compared to male pupils (21%) strongly believe that there should be more female engineers. Conversely, over one-quarter of male pupils (24%) disagree/strongly disagree that there should be more female engineers compared with 9 per cent of female pupils. More male pupils (13%) elected not to answer this statement than female pupils (7%).



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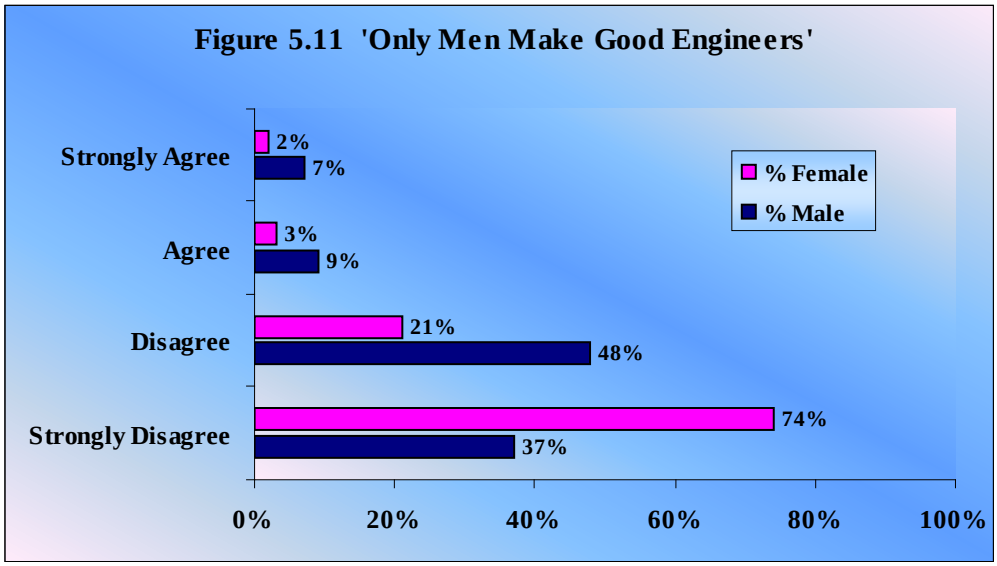
'Only men make good Engineers'

Differences between gender and 'only men make good engineers' are statistically highly significant. More than seven out of ten female pupils (74%) strongly disagreed that only men make good engineers compared with nearly two out of five male pupils (37%). Five per cent of female pupils and 16 per cent of male pupils either agreed/strongly agreed that only men make good engineers. As with other statements, more male pupils chose not to answer this statement.



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'A Female Engineer needs to act like 'one of the boys' to perform well in her Job'

Differences between gender and the statement that a 'female engineer needs to act like one of the boys to perform well in her job' are statistically highly significant. Over three-fifths (61%) of female pupils strongly disagree with the statement compared with 44 per cent of male pupils. More male pupils (15%) agree/strongly agree with this statement than female pupils (10%).

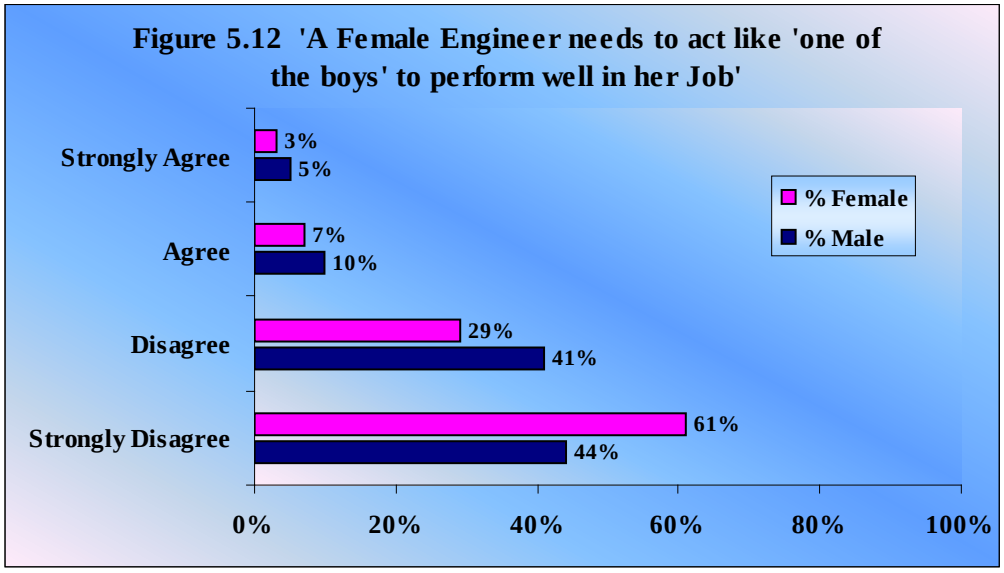

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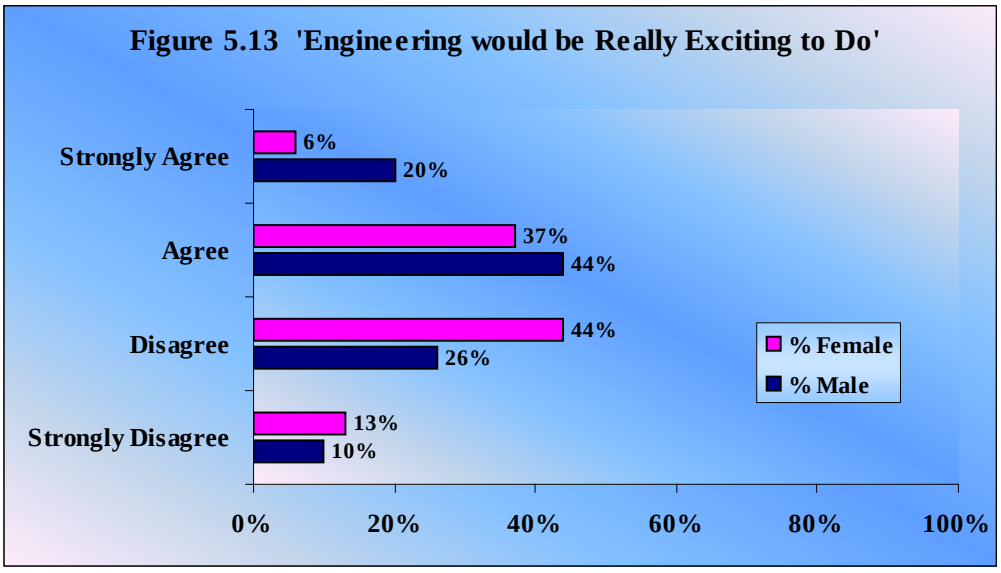
Table 5.14 describes students beliefs about certain statements relating to engineering. There are no statistical gender differences with each statement so each is described irrespective of gender. In total, 95 per cent of all pupils believe that engineers are well paid while the majority also believe that 'being an engineer allows one to travel and work abroad' (85%). Over two-thirds of pupils also have the perception that 'it would be easy to get a job if they were an engineer' and two-thirds of respondents do consider that engineers need to 'know about environmental issues'. Just over one-half of the respondents (56%) feel a person has to be 'really clever to study engineering'.

Table 5.14 Students Beliefs about Engineering

	Strongly Agree/Agree	Strongly Disagree/Disagree	Total
Engineers are well paid	95%	5%	100%
Being an engineer allows you to travel and work abroad	85%	15%	100%
It would be easy to get a job if I was an engineer	67%	33%	100%
Engineers need to know about environmental issues	66%	34%	100%
You have to be really clever to study engineering	56%	44%	100%

'Engineering would be really Exciting to Do'

Gender differences in the belief that 'engineering would be really exciting to do' are statistically highly significant. More than two in every five male pupils (44%) agree that engineering would be exciting to do while more than two in every five female pupils (44%) disagree with the statement that 'engineering would be really exciting to do'.



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In total, nearly two-thirds of the male pupils (64%) agree or strongly agree that engineering would be really exciting to do compared with two in every five female pupils (43%).

Both male and female pupils tend to see engineering as a secure profession, offering a person the chance to travel and work abroad, be well paid, find a job without too much difficulty, deal with environmental issues, work in a creative environment. Both male and female pupils also generally believe that engineering is not only for men and that many more women engineers should be entering the profession. Many of the statements regarding engineering have been answered very positively by the pupils yet significantly more male pupils still consider engineering to be an 'exciting' field to work in while many females do not consider this.

5.7 Perceptions of the Skills/Traits of an Engineer

5.7.1 Personal Traits of Engineers

Pupils were asked what the main characteristics that they associate with an engineer. They were given a list of ten characteristics and asked to pick three that they felt best described the characteristics of an engineer. The three most popular characteristics that male pupils used to describe an engineer are Creative (n=465), Clever (n=451) and Knowledgeable (n=447). The three most popular characteristics female pupils used to describe an engineer are Knowledgeable (n=759), Clever (n=718) and Creative (n=697) These results are set out in Table 5.15.

Table 5.15 Personal Characteristics of an Engineer

	Male	Female
Creative	465	697
Clever	451	718
Knowledgeable	447	759
Doing Something Important for Society	188	339
Friendly	138	207
Rich	110	154
Boring	62	91
Cool	53	42
Anti-social/shy	45	46
Geeky/Nerdy	45	42

5.7.2 Skills of an Engineer

Respondents were asked to select from a list the skills they feel are required to be a successful engineer. The responses are contained in Table 5.16. Both male and female pupils feel that the three most relevant skills for a successful engineer are 'hard working', 'organised' and 'smart'.

Table 5.16 Skills of an Engineer

	Male	Female
Hard Working	461	758
Organised	282	446
Smart	268	376
Analytical	216	375
Eager to Learn	215	271

Team Player	212	311
Patient	191	306
Knowledgeable	183	305
Good Communication Skills	158	241
Good Memory	93	194

5.8 Perceptions of Gender Roles in Different Professions

This section describes respondents' perception about the roles of men and women within society. Respondents were asked to state whether they felt particular roles are suitable for men only, women only or both men and women (Figure 5.14).

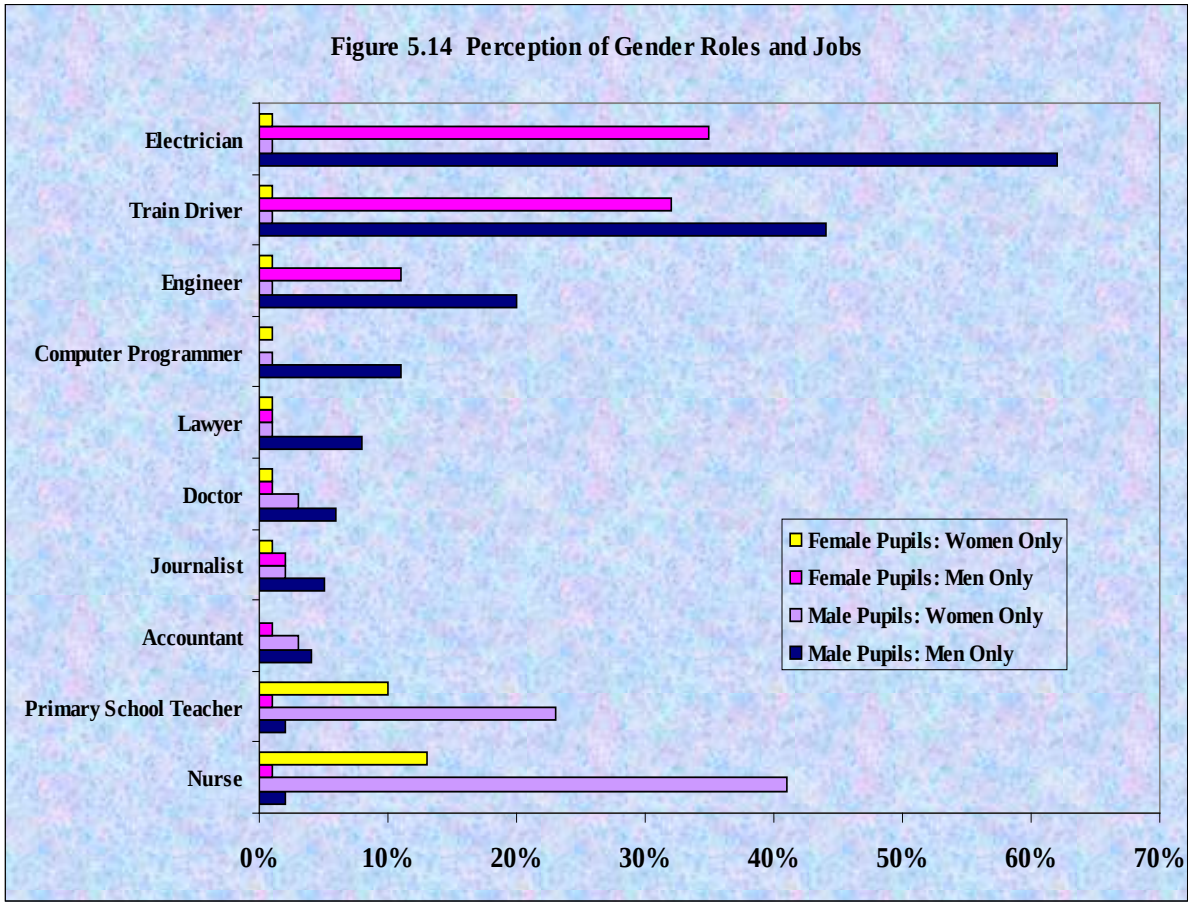


Figure 5.14 illustrates male and female respondents' beliefs about whether men or women are suited to particular professions. Three professions were highly gendered towards being 'male jobs' and two professions were gendered towards being 'female jobs'. Male pupils, and to a lesser extent, female pupils believe that electricians, train drivers and engineers are generally men's jobs.

Nearly two-thirds (62%) of male respondents and over one-third (35%) of female pupils believe an electrician's job is done by men. Nearly half (44%) of male pupils and just under one-third (32%) of female pupils believe that being a train driver is a man's job. One-fifth (20%) of male respondents and just over one in every ten (11%) female pupils consider engineering to be men's work.

Professions such as lawyer, doctor, journalist and accountant are perceived to be less gendered by respondents.

On the other end of the spectrum, over two-fifths of male pupils and 13 per cent of female pupils consider nursing to be specifically for women, while primary school teaching is considered to be a women's only profession by 23 per cent of male pupils and 10 per cent of female pupils

Male pupils in general tend to have a more stereotypical idea of what jobs roles are seen to be for 'men only' *and* for 'women only'. They tend to see men and women in more traditional job roles. Female pupils did not have such a strong stereotypical view of which jobs are specifically for men or women. The majority of responses by female pupils indicate that they considered most professions to be open to both men and women.

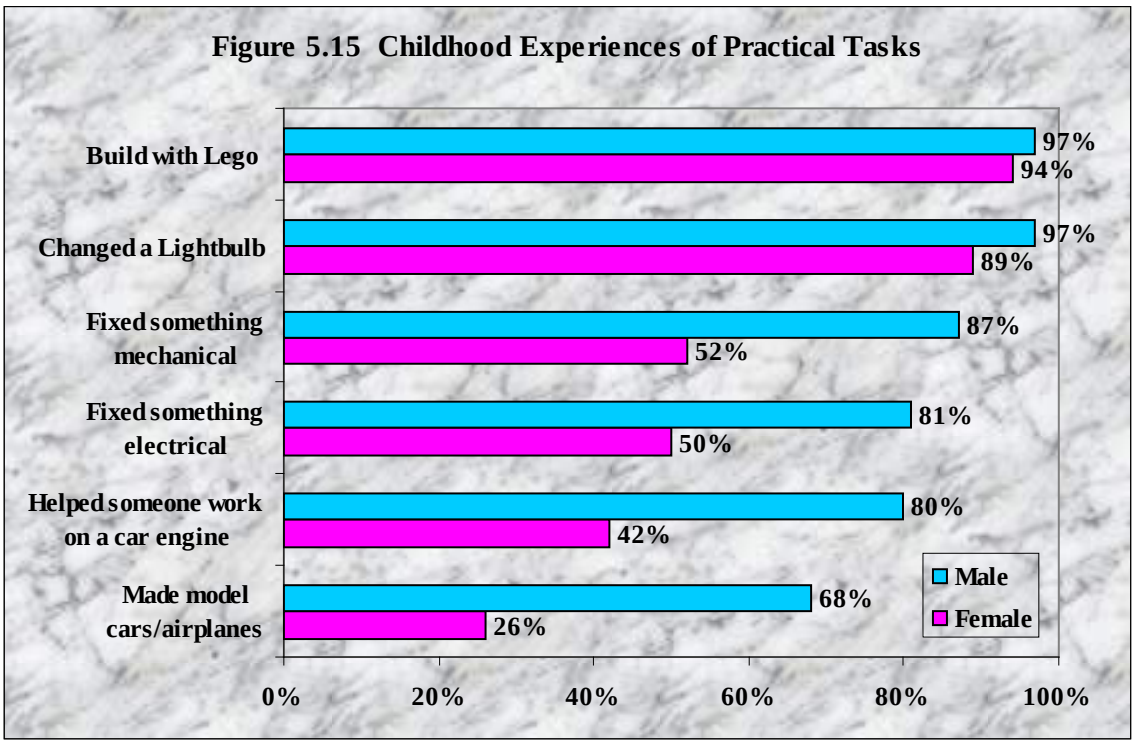
5.9 Exposure to Engineering

The literature from chapter three suggests that boys tend to have prior experience and exposure to playing at 'engineering type' activities which allow them to nurture their spatial and problem-solving skills. Girls are less likely to have access to the same type of experiences as boys so can be naturally excluded from developing the problem-solving skills so apt to engineering. This section discovers what experiences and exposure female and male pupils have had to some problem-solving activities.

5.9.1 Engineering Task Experience

Respondents were asked if they had been involved in playing with/fixing something practical during their childhood. The results are illustrated in Figure 5.15.

Figure 5.15 Childhood Experiences of Practical Tasks



The most common activity to male and female pupils is that the majority have *'built with lego'* with 94 per cent of female pupils and 97 per cent of all male pupils having played with lego.

The majority of male and female pupils have *'changed a light bulb'* yet significantly more male pupils than female pupils have changed a light bulb. Gender differences among respondents as to whether they have '*fixed something mechanical'*, such as bicycle brakes, are statistically highly significant. The majority of male pupils (87%) have experience fixing something mechanical while just over half of female pupils (52%) have similar experiences. Only 13 per cent of male pupils stated that they have not fixed anything mechanical compared with 48 per cent of female pupils.

Responses to the question about having experience *'fixing something electrical'* showed a similar gendered pattern of responses. The majority of male pupils (81%) compared with less than half (50%) of the female sample had fixed something electrical. More female pupils had no experience fixing something electrical (50%) compared to male pupils (19%). Differences between gender of a pupil and fixing something electrical are highly statistically significant.

Differences in the responses of female and male pupils to the question about *'helping out with work on a car engine'* are statistically highly significant. Four-fifths of the male respondents (80%) have helped someone work on a car engine compared with only two-fifths (42%) of female pupils. Conversely, only one-fifth of male pupils (20%) have not helped someone work on a car engine compared with over half (58%) of the female pupils.

Respondents were asked whether they *'made model cars or airplanes'*. Two-thirds of male respondents (68%) have made model cars or airplanes compared with only one-quarter (26%) of female pupils. Conversely, just over three-quarters of female pupils (75%) have had no experience making model cars/airplanes compared with just under one-third (32%) of male pupils. Differences between gender of a pupil and making model cars or airplanes are highly statistically significant.

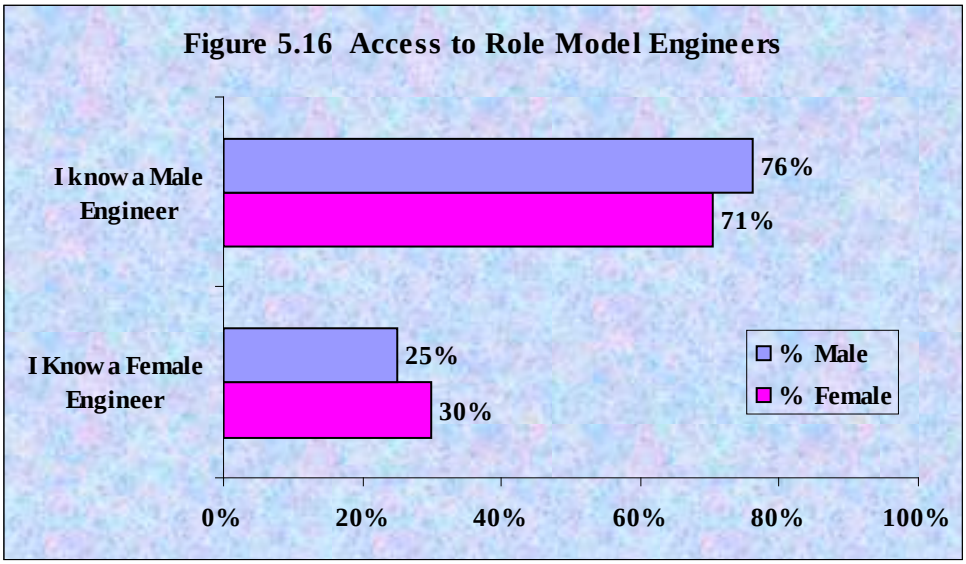
This section indicates that boys have had significantly more exposure to engineering type tasks and jobs prior to deciding which career they will embark upon. This points to their home environment and/or extracurricular activities as a place where the pupils have gained such experience and suggests that learning from a parent is very important in defining what play activities are considered acceptable for boys and not acceptable for girls, and vice versa. Parents may suggest that boys can help fix something mechanical or electrical but do not consider the same roles for girls.

5.9.2 Access to Role Model Engineers

Role models are considered important in helping to encourage female pupils to consider a career in engineering. A role model of similar background can give girls exposure to success stories that they can directly relate to and allow young women to see that they themselves could successfully pursue a career in engineering. Pupils were asked if they know a male and female engineer (Figure 5.16).

Among respondents to the question about knowing a male role model, three-quarters of male respondents (76%) and a similar proportion of female respondents (71%) know a male engineer. A higher proportion of pupils (271) elected not to answer this question.

Excluding non-responses (534) to this question, similar proportions of male and female pupils know a female engineer. Less than one-third of pupils (28%) know a female engineer. Marginally more female pupils know a female engineer (30%) compared with one-quarter of male pupils. There are no statistical differences between gender of a pupil and knowing a female engineer.



Both male and female pupils are more likely to know a male rather than a female engineer. Hence girls are much less likely to have a same-sex role model in engineering.

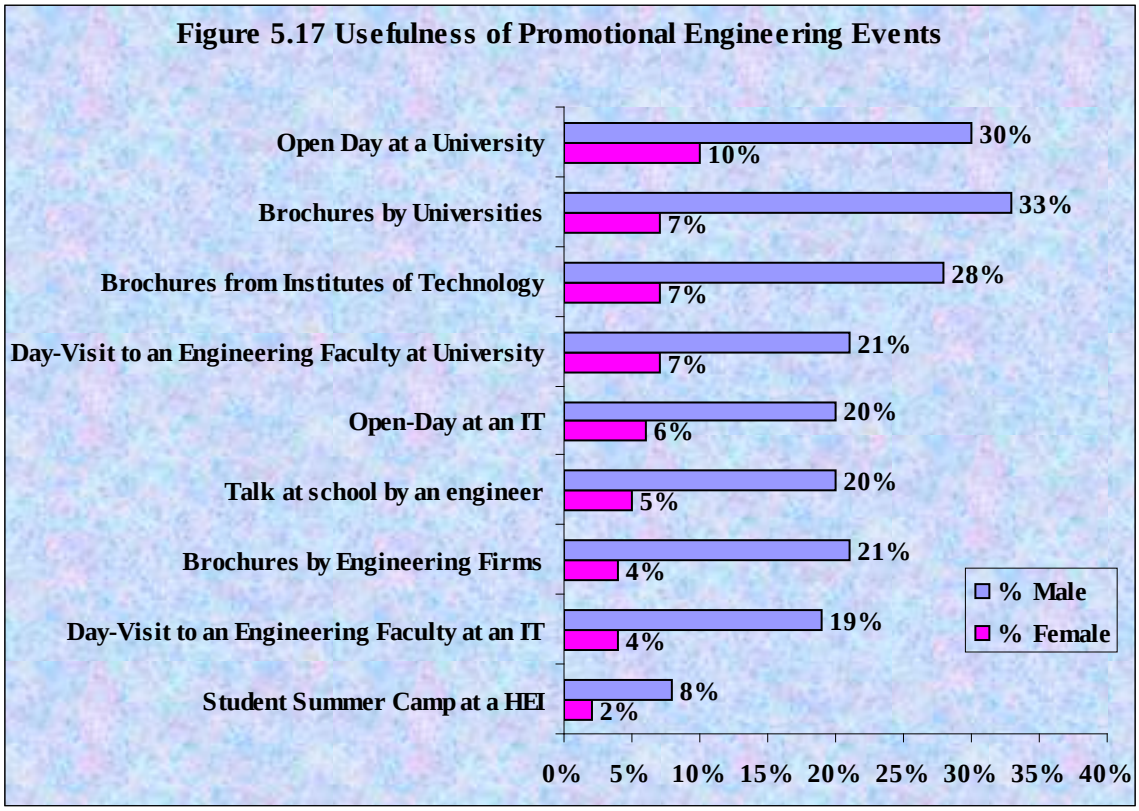
5.10 Access to Engineering Information

This section describes how useful Leaving Certificate pupils find material about engineering careers, courses and the profession itself.

5.10.1 Engineering Events

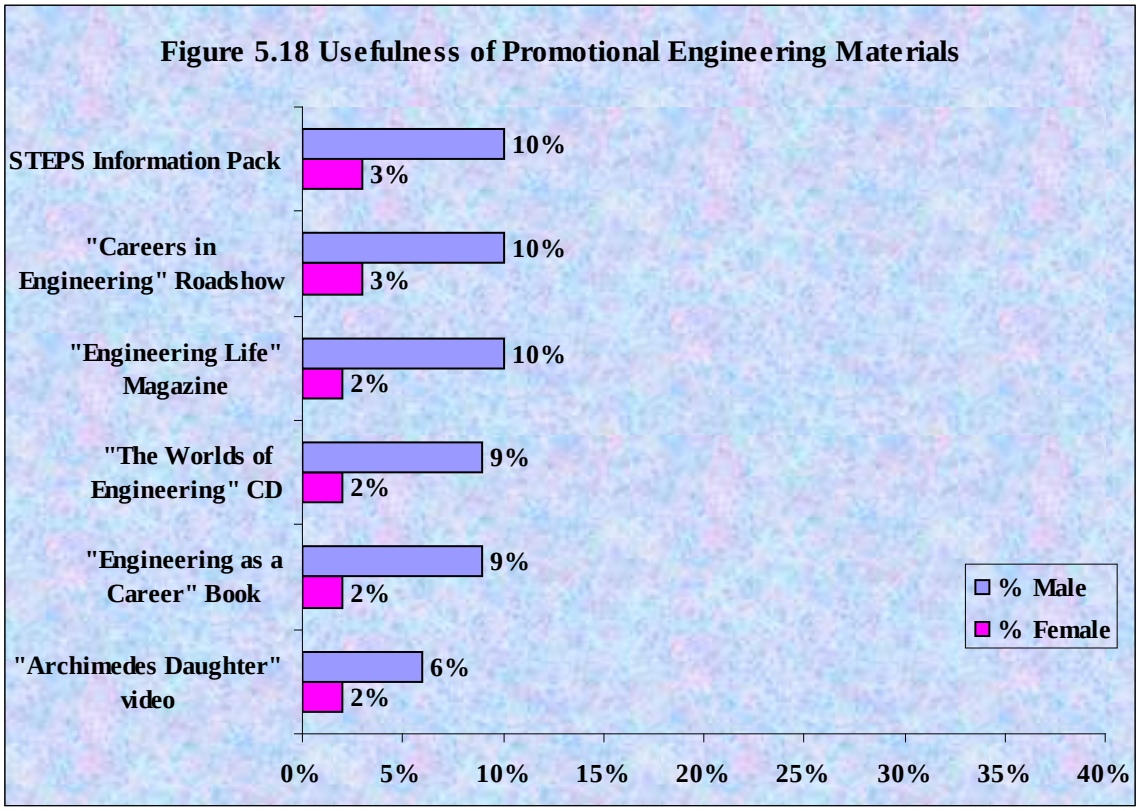
Pupils responded to how useful they found promotional engineering events organised by the engineering stakeholders such as universities, institutes of technology and engineering firms.

The most useful form of promotional events for female pupils is a *'general open-day at a university'* with 10 per cent finding this useful. Male pupils consider *'brochures by universities'* to be the most useful with 33 per cent of all male respondents finding this form of promotion to be useful. The least useful promotional event is a 'student summer camp at a higher education institution' with only 2 per cent of female pupils and 8 per cent of male pupils finding this useful. The low 'useful' ranking could indicate that students have not attended such an event so would not be able to comment on its usefulness (Figure 5.17).



5.10.2 Engineering Promotional Materials

The most preferred promotional materials offered by engineering initiatives and other interested parties is the '*STEPS Information Pack'* and the *'Careers in Engineering Roadshow'* also organised by STEPS. One in ten male pupils and 3 per cent of all female pupils found these materials and events to be useful in helping them understand engineering. "Archimedes Daughter" video, produced by the Department of Education and Science is considered to be the least useful with only 3 per cent of all female pupils and 6 per cent of all male pupils finding it to be a useful medium (Figure 5.18).



5.11 Views on Engineering

Students were asked if they had any final comments that they wished to share about engineering in general.

5.11.1 Comments from Male Pupils about Engineering:

Some male pupils commented on the perceived challenging environment of engineering:

> *"Engineering is generally perceived as a difficult occupation. Working on a building site – an engineer's job seemed very mathematical and complex, but with good prospects"; "Engineering is an interesting career but sometimes it's very challenging being recognised as an engineer because of the high qualifications required".*

Other male pupils discussed their own lack of knowledge about engineering and hoped that there would now be more awareness of it:

> *"Engineering should be made more attractive to young people and be explained a lot more often"; "Hope there is more awareness made of information in schools as many of us don't know what engineering is or its qualifications"; "Young people don't actually know what engineers do".*

Only a few male pupils mentioned that girls should consider engineering:

> *"Engineering is an important part of society and should be open to anyone as a career choice"; "Women should be more open to doing engineering".*

5.11.2 Comments from Female pupils on Engineering

Many more female pupils had final comments to add to the questionnaire on varying subjects.

Many female pupils discussed their awareness of the 'male' environment of engineering and how this has affected their career choices and their views on engineering:

> *"aware that engineering is centred around men but I do know two girls studying it"; "Career should be aimed more towards women rather than just men"; "Engineering is a more male dominated career, only for that, I would consider it"; "Engineering is for smart boys and if I went for it, I would get strange comments"; "Engineering is not explained or advertised well or encouraged in my school or many other schools as an option for girls. The advantages are not shown clearly to encourage girls to do it"; "Engineering is only seen for males for the simple fact the thought of 'that' work is off-putting for girls. I think it starts from childhood, girls don't usually play with boys toys"; "boys have the mentality that girls shouldn't do it [engineering] but I think girls are trying to do it more"; "Interested in engineering but not as a career. Does appear to be a very male orientated profession"; "many women don't work as engineers as they'll feel left out if there are no other female on a site".*

Other female pupils discuss their lack of knowledge about engineering:

> *"Did not consider engineering before but after doing this [completing questionnaire], it has become more appealing"; "Don't know anything about engineering so can't say anything"; "Don't know much about engineering"; "Don't know what an engineer does. Are they the same as an architect?"; "Engineering is not widely understood"; "Not enough information on engineering"; "General information about engineering is very poor. Majority of students don't know what an engineer does"; "think a lot of people are very uninformed about engineering and the common belief is engineers = engines".*

While other female pupils are aware that their lack of higher level maths or subject choice places restrictions on their ability to study engineering at third-level:

> *"Feel just having pass maths closes off many doors"; "If universities want engineers, they must lower the points requirements. There should not be such a huge jump in points in higher and ordinary levels. What if people were suited to a job but subject [choice] e.g. music/art, let them down?"; "In an all girls school, we do not have engineering as a subject, which is wrong"; "Would have loved a career in engineering however due to the educational system in this country, I am unable to fulfil my ambition as I do not study honours maths".*

Female pupils also offered their advice on what measures could be adopted in order to help promote engineering for women:

> *"Engineering should be advertised more and made more appealing for women"; "Girls schools need to offer more practical subjects. Students don't know if they have a flair for engineering"; "it might be beneficial to produce a brochure on what types of engineering there is and what they involve as people don't know what it is"; "make engineering more clear to girls at a young age"; "more effort should be made to promote the various kinds of engineering and the job opportunities available"; "need more information on careers in schools"; "The role of an engineer and work involved should be explained then it may interest them"; "there should be more information available which would encourage them to do engineering. Course looks very boring to us. There should be less emphasis on maths/physics even though this is a big part of*

the course"; "you need to give courses a higher profile as well as promoting possibilities and showing students that it is not all about complicated physics, maths etc.".

5.12 Key Findings

A large-scale survey of male and female Leaving Certificate pupils showed the following:

- Significantly fewer female pupils are studying higher-level maths (19%) compared with 28 per cent of male pupils. They believe that both higher-level maths and physics are pre-requisites for studying engineering at third level.
- While half the male pupils considered engineering as a career only one in ten female pupils considered engineering. If offered a place on an engineering course, one quarter of male pupils would accept while only three per cent of female pupils would do the same.
- Boys are deterred from applying to study engineering because they feel they are better at other subjects; do not have the pre-requisite subjects; and have no interest or knowledge about engineering. Girls are deterred from applying because they believe engineering is 'only for males'; they are better at other subjects; have had poor career advice about engineering; do not have the pre-requisite subjects; and have little interest in, or knowledge about, the profession.
- Both male and female pupils consider their fathers to be the most influential person in their consideration of a career in engineering, followed by guidance counsellors and then their mothers. More than half of male and female pupils agree that: one '*does not have to be really clever to study engineerin*g'; '*engineers do need to know about environmental issue*s'; and '*it would be easy to get a job if studying engineerin*g'.
- The majority of male and female pupils agree that: '*engineers are not considered nerds at schoo*l'; '*engineering is a creative professio*n'; and '*engineers are well paid*'.
- Significantly more female pupils agree that '*there should be more female engineers*' compared with male pupils and significantly more female pupils disagree that: '*only men make good engineers*'; and '*a female engineer needs to act like one of the boys to perform well in her job'*, compared with male pupils. However positively pupils view engineering, girls still do not feel it would be '*exciting'* to do engineering.
- There is evidence amongst second level pupils of adherence to strong gender-stereotypes for certain occupational roles. Electricians, train drivers and engineers are perceived to be jobs for 'men only' compared with primary school teacher and nurse which are seen as 'women only' jobs. Male pupils appear to have more fixed and gender-stereotyped ideas about the suitability of traditionally 'male' and 'female' professions.
- Male pupils have much greater exposure to 'tinkering' and engineering type tasks prior to entering third level than female pupils, including fixing something mechanical or electrical. Both male and female pupils are more likely to know a male, rather than a female, engineer which reinforces the claim that there are fewer women role models for female pupils.

6. Focus Groups

6.1 Introduction

Focus groups are generally used to gather data relating to the feelings and opinions of a group of people who are involved in a common situation (Collis et al. 2003). In this study, focus groups explored the feelings and opinions of senior cycle pupils about their career paths; careers in engineering and general perceptions and ideas of engineering.

6.2 Focus Group Methodology

Senior cycle (fifth and sixth year) pupils participated in the focus groups. The senior cycle pupils were targeted as they are in the process of making their career decisions. The aim of the focus group session is to find out the participants thought process on choosing a career and also, what their opinion is about engineering and how this opinion is formed.

Four focus groups were held in three schools during March and April 2004. The schools were contacted by phone requesting permission to run a focus group during those months. The school contact was asked to randomly select senior cycle pupils. Table 6.1 indicates that two single-sex schools were targeted and one vocational school, with one male-only and one female-only focus group run in this school. Metalwork and engineering is not a subject offered by either of the secondary schools yet the vocational school does offer these subjects.

Table 6.1 Details on Focus Group Participants

School Type	Gender of Pupil	Number in Focus Group	Metalwork available	Engineering available
Secondary	Female	7	No	No
Secondary	Male	8	No	No
Vocational	Female	9	Yes	Yes
Vocational	Male	9	Yes	Yes

The group members were introduced and were told the purpose of the study. The group were allowed to discuss each question amongst themselves but the interviewer intervened at times to ensure all participants aired their views. A prepared list of topics was covered throughout each hour-long focus group. One observer recorded the proceedings by taking hand written notes.

6.3 Career Aspirations

Pupils were asked if they had decided what courses they were going to apply to at third-level.

Male pupils from the in the single-sex school did not have a focused idea about which course they plan to study at third-level. Most of the participants gave a choice of two courses such as:

- *"Law or psychology";*
- *"Business or law";*
- *"Medicine or engineering";*
- *"Law or medicine";*
- *"Business or medicine".*

All pupils want to study in Dublin yet did not give such a strong preference as to which Higher Education Institution they would attend. In contrast to the all male pupils attending the co-educational school know what career paths they will pursue. Careers include:

- *"Mechanical engineering";*
- *"Cadet in the army";*
- *"Civil engineering";*
- *"Apprenticeship as a mechanic";*
- *"General engineering in Bolton Street".*

There was a range of courses mentioned by female pupils. These included:

- *"Hotel & catering";*
- *"Science";*
- *"Radiography";*
- *"Engineering";*
- *"Speech therapy";*
- *"Sports management";*
- *"Law".*

All the girls had strong opinions as to the course they wished to study and knew which university they planned to enter. Some female pupils did not have a clear idea of what they would do once they finished school. One participant wants to study law while another wants to study psychology. The remainder did not know what they would career path they would take.

6.4 Course/Points Requirements

Pupils were asked if they knew what Leaving Certificate subjects are a mandatory requirement to study engineering at third-level. There were various responses from each of the different groups including Higher Level:

- Maths;
- Physics;
- Applied maths;
- One science (either chemistry or physics);
- A1 in Ordinary Level Maths.

There was a general agreement from the all-male focus group that *"Higher Level maths"* is a requirement to study engineering. Female pupils agreed that *maths* was a requirement to study

engineering but one pupil did mention that it depended on the university as to whether a pupil needs Higher Level maths or not. The results from the Leaving Certificate pupils surveyed also noted that higher level maths is a pre-requisite for most engineering courses, and they were aware that other subjects might be beneficial to a student wanting to study engineering at third-level.

6.5 Choosing Engineering at Leaving Certificate

Pupils from the co-educational school were asked to comment on why they did/did not choose engineering as a Leaving Certificate subject. The fifth year engineering class has 29 male pupils and only one female pupil taking this class. The two focus groups held in this school allowed an in depth discussion as to why the ratio was so male-dominated

All male pupils from the group are studying metalwork or engineering. The participants have chosen these subjects because they are *"fun"* and *"looks good on the CV"*. The sixth year pupils found engineering to be much more enjoyable in sixth year because they have a project to do while in fifth year, they found it to be very theoretical based. One pupil wants to study engineering at college because he *"like making things"* while another *"likes computers and cars"*.

The only female pupil who chose engineering at senior cycle said that *"engineering in school is a laugh, it is very interactive and the exam is predictable"*. Many of the female pupils found metalwork difficult. They said that 9 out of 10 female pupils in their school did metalwork for the Junior Certificate but only 2 out of 10 are taking engineering for the Leaving Certificate. Some felt that doing metalwork *"turned them off"* doing engineering.

Others felt that engineering is a *"difficult subject"*. One felt that she was *"afraid to study it as there is a lot of pressure and you have to be so accurate"*. Another felt she *"couldn't learn all the definitions"*. Two pupils mentioned that the engineering teacher is *"very scary if you got something wrong"* yet another felt the teacher to be *"very encouraging but I did not want to study engineering because I do not want to be the only girl"*.

6.5.1 Why so Few Girls in Engineering Classes?

At the co-educational school, male pupils were asked why there is only one female pupil in their fifth year engineering class. The reasons given by the male participants include:

> *"society"; "none of their [female] friends do it"; "guys prefer engineering"; "women aren't good at building" "girls are better at maths, drawing graphs and are neater, they are better at the theory aspect of engineering"*.

One female pupil found engineering to be a very *"physical"* subject and *"very physically demanding"* at Leaving Certificate level. She explained that she *"found it very difficult to cut into metal"*, which was a disadvantage at exam time. She enjoyed the theory of engineering.

The male participants believe that a girl who does engineering *"knows what she wants"* and has a *"strong personality"*. They all think it would be difficult for a girl to go into a class and be in the

minority yet they claimed to be indifferent to having a girl in their engineering class. They believe that girls *"listen more to their friends whereas guy's mates would not influence their subject choice"*.

All of the female participants agreed that their female friends are the main discouragers to studying engineering for the Leaving Certificate. *"Our friends turn us off doing it"* by saying, "*why would you want to do engineering?"*. They felt that girls being in the minority in class might feel intimidated and isolated.

Two female pupils commented that their father reacted differently when told them that they dropped engineering. One father "*gave out to me for dropping it*" while another "*gave out to me for picking it*". This pupil's father is a mechanic and wants her to "*have a 9-5 job, a job that is clean*". The pupil believes though that "*much of engineering is now computerised*".

Despite the exposure metalwork at junior cycle and engineering at senior cycle, most of the female pupils are not taking engineering or considering a career in this field. Some pupils felt that if more female pupils were taking engineering, then they would consider it. One girl suggested having a *"female engineering teacher"* would be a positive influence. The teacher would be seen as a *"role-model"* and demonstrate that *"[Engineering] may not be just a guy's thing"*.

6.6 Choice of Engineering at Third-Level

Pupils were asked why they would/would not consider applying to study engineering at third-level.

Male pupils were influenced by **work experience** they did in transition year. One participant worked in a law firm and he is now considering applying to law. Another boy worked in a hospital and he is applying to medicine. The Transition Year work experience reflects the courses pupils plan to study at Higher Education Institutions.

Only two out of the seven female participants from the single-sex school would consider applying for an engineering course through the CAO system. The remaining five did not consider engineering. The reasons given ***for choosing*** to apply to an engineering course were:

> *"love maths and applied maths"; "[I] have a very logical mind and love looking at how things are put together and how they work"*.

One respondent said she did not get any advice on her decisions from anyone while another said a friend's sister is an engineer and this influenced her decision.

The reasons given for ***not choosing*** to apply to an engineering course were:

> *"don't know what it is"; "portrayed as a male career, and has never looked it up, despite doing honours maths"; "felt it has a lot to do with building"; "father is an engineer and what he does doesn't interest me – [I] find it boring and associate engineering with building and computers"*.

These comments are in accordance with findings from Chapter 5, indicating that female pupils do not consider engineering because of lack of knowledge and that it engineering is perceived to be a male-only industry.

6.7 Perceptions of Engineering as a Profession

6.7.1 What do Engineers Do?

The male pupils described engineering as someone who *"works on a building site"; "designs roads and builds roads"; "makes sure buildings don't fall down"*. Others could not describe what an engineer does because it *"depends on the type of engineer"*.

Female pupils described an engineer as someone who:

"puts ideas into reality"; "helps construct things (bridges)".

Participants could also name different types of engineering including: *"electrical"; "biomedical"; "aerodynamics"; "mechanical engineers"*. Other female pupils could not give any description of what an engineer does, stating, *"I don't know"* as the answer.

6.7.2 What do Pupils Associate with 'Engineering'?

Pupils were asked to associate words with the "engineering". Male pupils did not give specific words when asked to describe engineering though two pupils felt it would be *'stressful'*. Based on his father's behaviour as an engineer, one pupil believed it is a 'stressful' job. Another pupil agreed stating that his aunt is an engineer and she also gave the impression that engineering is a stressful profession.

Words that male pupils associate with engineering include "*Metal; Building; Bridges; Construction worker; Career; Money; and Computers*".

Female pupils associate active words to an engineer such as *"numbers; plans; drawings; logical; maths; buildings; computers; Building site; Man; Muck; Under a car; Wires & electrical"*.

All female pupils agreed that the word "*man"* was present when they thought of 'engineer' and admitted that it could subconsciously influence their decision to choose engineering.

6.7.3 Profile of an Engineer

Pupils were asked what type of person they think does engineering. Male pupils described an engineer to be:

"a nerd, a problem solver, and usually male"; "physical, outgoing, team-worker, understanding, able to manage a team, not isolated, a man".

while female pupils describe an engineer to be:

"*logical, intelligent, creative and technical"; "can't picture a woman as an electrician or a builder"; "women would get a lot of stick from workers on site"*.

Male pupils mentioned 'problem solver' as a key characteristic of an engineer. The female engineers in the case studies (chapter 7) describe their role as an engineer to be a 'problem solver'. Chapter 3 highlights the importance of 'problem solving' of engineers to a sustainable knowledge based economy. The Leaving Certificate male and female respondents (chapter 5) did not consider an engineer to be a 'nerd' but they did see an engineer being 'creative'. Further comments from female pupils, in chapter five, did show their concern about entering such a male-dominated domain.

6.7.4 Perception of the Engineering Environment

Male pupils perceive studying engineering at college as involving:

"long hours"; "vicious"; "all male"; "horrible compared to BESS"; "a lot of exams"; "laddish, with no girls to calm the boys down",

While female pupils describe the environment of engineering at college to be:

"9-5 every day"; "tough for a girl – there are a lot more males than females in the class so females might feel they have to prove themselves more"; "people perceive them [engineers] as being nerds who don't go out".

The female engineers from the case studies (chapter seven) also commented on the 'laddish' culture of engineering where a female had to put up with being in the minority amongst men. The notion of female students having to 'prove themselves' is

The image of an engineer described by the focus groups indicate that an engineer is generally a man, works very long hours, slightly nerdy, but logical, technical and manages a team well. The main work an engineer does is working on a building site, or building bridges and roads and gets quite dirty. Only one person from all the focus groups mentioned that an engineer works with computers.

In general, this is a very strong image of an engineer and is similar to Yurtseven (2002) who investigated the image of engineering and found that that the US public see an engineer as 'predominantly male, too bright for their own good, honest to a fault, non communicative, dull and loners'. This image needs to be addressed for young women to be able to see themselves in the role of an engineer.

6.8 Societal Roles of Men and Women

Pupils were asked to describe the role of men and women within engineering and also if there were any jobs specifically assigned only to men or women.

6.8.1 Gender Specificity of Jobs

At school level, male pupils think their female counterparts are better at subjects such as *"home economics"*. They feel that there are jobs specifically for women but also jobs specifically for men. They consider women to be better at jobs like *"nursing and teaching at primary school"*. They believe men would get more *"frustrated"* than women teaching primary school children. This perception is in agreement with the findings from chapter five, where male pupils also consider roles

such as primary school teaching or nursing to be primarily for women. Men, they feel, are better at *"labour"* jobs and are more likely to be engineers. The male pupils from the co-educational group thought that both men and women can do jobs such as a doctor and a lawyer but they associated the profession *"accountant"* as being a male profession.

All of the female participants **do not believe** that there is jobs men can do better than women. The pupils felt that men think that they can do jobs better than women but they did not believe this to be true. Conversely, some female pupils **do believe** that there were jobs that women can do better than men. These roles included Montessori teaching or working with young girls. The participants suspect women have not had the chance to work in male-dominated jobs due to lack of exposure of the jobs and lack of opportunity.

The findings from chapter 5 also showed that male pupils in general are inclined to have ore stereotypical idea of what jobs roles are seen to be for men only and for women only. The male pupils have tended to see men and women in traditional job roles. Female pupils did not have such a strong stereotypical view of which jobs are specific for men or women. The majority of responses by female pupils was that they considered most professions to be open to both men and women.

6.8.2 Obstacles for Women Studying Engineering

Most of the male pupils consider that it might be difficult for a woman to do well in engineering. One pupil believes that *"women give up easier"* as he had been told this by a male teacher in the school. Other reasons include:

> *"it may be more difficult for a woman to order men around, for example, when working on a building site"; "it would be harder for a female pupil in an engineering lecture as she may feel out of place"*.

Only one of the eight respondents thinks women can do well in engineering because *"employers want women because they want to have equality in the workplace"*.

Female pupils believe it is more difficult for female students to do well in engineering, in particular pupils coming from an all-girls school. The participants think that attending engineering lecture with the majority of the class being male would be *"very intimidating"*. They consider that a woman entering a more *"woman based profession"* such as nursing or teaching would have an easier time with the course because there would be more girls to connect with.

6.8.3 Image of a Woman Engineer

The general consensus amongst all-male focus group participants is that a female engineer is: *"a tomboy, butch"* and *"doesn't take crap from the lads"*.

When discussing who would make a better engineer, a man or a woman, male pupils had differing from each other on this issue. Some felt that women would make a better engineer because so few women enter engineering, that those who do are more *"driven"* than men. Another male pupil was of the opinion that women are *"harder workers yet they do think differently to men"*. One pupil felt *"guys go into engineering by default"*.

Female pupils believe that men and women would be performing the same job but *"a man would get a better job because sexism will always exist"*. The majority of female respondents consider that women have to work harder to impress and to get respect from men in the engineering profession.

6.9 Influences on Career Decisions

Participants were asked to discuss who and what are the major influences on their career decisions.

There are various people involved in helping male pupils make a career decision. These include parents and relatives working in a particular field/profession. Most pupils found the aptitude tests that were completed in Transition Year to be a useful indicator as to what jobs would suit them. All participants found the aptitude test (DATS) results useful in helping them to decide to take engineering as a subject in school *(co-educational school)*. In the co-educational school, pupils create a career portfolio for their guidance counsellor class on an area that they are interested in so all pupils had completed research on their respective career choices.

Some pupils found that they were turned off certain careers because their parents work in that area. The male pupils did not find teachers or career guidance counsellors to be of particular importance in helping them make a career decision. Some of the male pupils suggested that *"nobody"* has helped them make their career decisions. They say they "*chose courses myself*".

Female pupils named many people as important influences in helping them make a career decision, including school and external guidance counsellors, parents, older brothers or sisters and friends. The female pupils gained their knowledge about engineering from home, television, career guidance and the Internet. Television did not influence their choices but it helps to "*glamorise the professions*". All the participants found the guidance counsellor useful for providing information yet they did not find their aptitude tests to be a very good indicator on what careers they would be applicable for.

6.10 Views on Engineering Promotional Material

Focus group participants were asked to comment on engineering promotional material. The male pupils would not be interested in reading brochures or watching videos about engineering and engineers. They would like an engineer to talk to them about the profession because they would be able to ask questions. All male participants from both groups preferred a speaker to show them practical applications of engineering. One pupil noted that:

> *"a boring speaker would put them off the job"*

and other participants agreed with him.

Some male participants had heard of STEPS and had attended a STEPS programme. They did not find it to be very good this year. They would have preferred if they had gone to an engineering company and had a talk by an engineer so that they could "*see what engineering is like*". Most of the male pupils attended an Open Day (at UCD) but none attended any engineering talks at this because

they were only allowed off school for four hours to attend. They would take note of engineering stands at Open days if *"free things were distributed from engineers such as pens or lollipops"*.

Female participants had read engineering materials published by universities. The engineering talk at UCD was noted as being *"excellent"*. All pupils agreed that they would like to:

> *"talk to a female engineer and a pupil engineer"*.

They believe that talking to someone who does the job would affect them more than just reading up on it. They would like a female speaker to come to schools in fifth year. They feel that the problem with women not entering Engineering is that:

> *"not enough people know what engineering is"*.

Only one of the female pupils knew about STEPS and attended a programme this year. The remainder of the participants had not heard of STEPS. Most of the pupils would like a talk or a video by *"a male and female engineer to give both their perspectives"* on engineering.

6.11 Conclusions

- Male pupils attending the single-sex school did not know much about engineering. As one noted, men veer towards engineering as a *'default'* career because it is traditionally male-dominated, even if they know little about engineering.
- The male participants attending the co-educational school had a stronger idea of what engineering is and what the profession entails. All pupils present are considering a career in engineering.
- They did question why so few girls study engineering in their school but also admitted it would be quite difficult for a girl to be in the minority as she might be the *"butt of some jokes"*. They had specific knowledge about each of the disciplines within engineering. They all generally had a very positive attitude towards the profession.
- Those female pupils interested in engineering tended to know the different types of engineering courses, what subjects and level are needed and the promotional material available.
- The female pupils uninterested knew very little about the career and had gained their knowledge about engineering purely from society and the media.
- All female participants attending the co-educational school had access to metalwork at Junior Level yet only one pupil of the group chose to continue engineering for a Leaving Certificate subject.
- All the female pupils had a general knowledge of engineering and knew what subjects were required to study it at third-level.
- They generally had a very positive attitude to engineering and felt that all women definitely could do engineering. However, when asked why they did not choose it, they just said *"it isn't for me"*. The impression from this group was that they do believe a woman can make a good engineer but just "not me".
- The main negative influence deterring girls from choosing engineering appeared to be their female friends at school who would question why a girl would choose this course.

- All members of the focus group would like an engineer to talk to them about the profession because they would be able to ask questions.

7. Case Studies of Female Engineers

7.1 Introduction

A case study is an extensive, in-depth examination of a single instance of a phenomenon (Collis et al. 2003). Each phenomenon and characteristic held is described in section 7.2. The purpose of this chapter is to understand the phenomena within each particular context. The case study approach in this instance is to understand women who are qualified engineers, their career histories and motivations for becoming an engineer.

7.2 Case Study Methodology

The objective of holding one-to-one interviews with persons with expert knowledge in this field was to discuss why female school leavers do not enter engineering at the same rate as male school leavers, based on their experiences in engineering. The interviewees were also asked for any suggestions for measures and action that could be used to address this issue. Interviews were held with women who have an engineering qualification to trace their career histories and motivations for becoming engineers.

Four women were interviewed between March and May 2004. The first female interviewee works in the private consulting sector of engineering. She is referred to as 'Amy, the consultant engineer'. The second engineer has an engineering degree but chose not to continue working in engineering. For the purpose of this study, she is referred to as 'Barbara, the former engineer'. The third female engineer works in academia and is known as 'Christine, the academic engineer'. The fourth female engineer was selected because she works in a public utility on an engineering plant site. She is referred to as 'Deirdre, the site engineer'.

The format of the interview was semi-structured (Appendix X.X with Interview Checklist of Questions). Semi-structured interviews are not standardised. The interviewer had a list of themes and questions to be covered, although they did vary from interview to interview (Saunders et al. 2003). Some questions were omitted or changed slightly depending on who was being interviewed. The nature of the questions and the ensuing discussion meant that the interviews were recorded using handwritten notes. Each interview lasted between 1-2 hours.

7.3 Case Study of the Consultant Engineer, Amy[*]

7.3.1 Family Background and Education

The consultant engineer, Amy, is 31 years old and was educated at an all-girls school. Her father was a bank manager in and her mother was a housewife. She has three older brothers and no sisters.

At school, Amy was very good at maths. Her guidance counsellor advised her to study accounting at University but she did work experience in Transition Year in accountancy and did not enjoy it. She

[*] The name has been changed to protect anonymity

felt her next obvious choice was to study engineering. She attended a Dublin based University to study civil engineering for three years but moved to environmental engineering by fourth year. After qualifying in 1995, she completed a Masters degree by Research.

7.3.2 Role-Models and Influences

Amy's female maths teacher provided a strong role-model for her. This teacher taught her every day at secondary school. Her maths teacher was a good role model because she pushed each student to her maximum potential. She received no specific encouragement or discouragement from family members or her friends to study engineering. Her parents expected Amy to study at a university.

She now considers having a mentor as being very important. Amy would consider her boss (female) as important in shaping her ideas. Amy defines a mentor as being *"someone who understands the profession and someone you can trust completely"*.

7.3.3 Career Development and Promotion

Amy now specialises in environmental engineering in which female engineers working are prominent. She feels that some people claim that environmental engineering is "*not real engineering*". She sees it as *"strategic, problem solving as opposed to looking at formulae all day and number-crunching"* which suits her personality. The company she works for believes that a person either *"fits"* the company or they do not.

7.3.4 Work-Life Balance

Amy was promoted this year to management level. She was the only female engineer to have been promoted. She feels that, within her company, women take one to two years longer than men to reach managerial level. She could not give a reason for this. Managers are expected to be *"bringing in the work"* and *"working productive hours"*. None of the female managers in her firm are married or have children. They all work long hours and do a lot of socialising and entertaining clients. All of the male managers are married and have children.

She is relieved to have become a manager before having children. She feels that flexitime may not help a woman's promotional prospects. She also thinks that women's priorities change once they have a child. She sees herself in the future as *"managing people"* more than being an 'engineer'.

7.3.5 Why Amy is successful in her career

Amy feels she has "*great knowledge in her field*", which was gained partly through her studies for her Masters degree. She also thinks she is very confident saying that *'I am bolshy enough!"*. She thinks she is not a shy person and has the confidence to speak her mind. Others do not intimidate her, since she also *"makes my own opportunities by networking, going on courses and following up on contacts"*.

7.3.6 Culture and Image of Engineering in the Private Sector

She considers engineering to be an undervalued profession, especially civil engineering, with architects, surveyors etc. viewing engineering *"one up from the tradesmen"*. According to Amy, engineers see environmental engineering as *"being a nuisance"* in particular, because it is a relatively new branch of engineering in Ireland. She cites the view that *"Joe Bloggs does not know what an engineer does"* and that there is *"no definition of engineering"*. Amy thinks that the engineering

profession can no longer be seen as *"jack of all trades"* as there are now so many different branches of engineering that are disciplines in their own right.

From her experience, Amy feels that women are attracted to the more managerial/strategic aspects of engineering while men enjoy the analytical and *"number crunching"*.

7.3.7 Women in Engineering

Amy feels that a girl who does choose to study engineering has to be a *"little more hardy than average"*. While doing engineering, a person may be thrown into any job type (e.g. *"abseiling down a cliff/looking through people's bins").*

She feels a lot of women in engineering are *"aggressive"* and do not know how to deal with being a minority without displaying aggression. She thinks that when a person is being aggressive, others stop listening and that aggression comes from being insecure in oneself. *"A person in engineering needs to be confident, not arrogant".*

7.4 Case Study of the Former Engineer, Barbara*

7.4.1` Family Background and Education

The former engineer, Barbara, is 27 years old and was educated at an all-girls convent school. She has one sister and one brother. At school, she was very good at maths. She chose actuarial studies as her first choice in her CAO because she thought it was for *"mathsy"* people. Mathsy people are those *"who like pure maths and not just science"*. She decided to be an actuary because she really enjoyed her work experience in an actuarial firm during Transition Year.

Engineering was the second choice on her CAO form. She was encouraged to choose engineering rather than science because she was told that if she did not get actuary, she could study engineering and after her degree she could get exempt from some of the actuarial exams because of the strong maths content in engineering.

She was offered her second choice, engineering, and attended Trinity College Dublin because it had a more general programme allowing her to get a broad overview of what engineering is about as she felt she had no experience/knowledge of engineering. She graduated from Trinity in 2000 and is now studying for her actuary exams with an insurance company.

7.4.2 Role-Models and Influences

Barbara said her maths/physics/applied maths teacher was her greatest influence. He was a qualified engineer. He advised her which subjects to take for her Leaving Certificate exams. He recognised that she was "better at formulae rather than artsy type subjects".

Barbara's parents did not really guide her towards engineering. They were supportive to her whatever her career choice. Her guidance counsellor suggested actuarial studies after Barbara sat her Differential Aptitude Tests for Guidance (DATS-G). She had very high scores (except for spatial

* The name has been changed to protect anonymity

reasoning). Her guidance counsellor did not specifically steer her away from engineering but she did not advise her to choose it either. Barbara felt that her guidance counsellor did not offer her enough options, steering her to mainstream professions.

7.4.3 Culture of Engineering at University

When Barbara started university, there was a ratio of 1 female: 4 male students. She studied mechanical engineering and the ratio reduced to 1 female: 5 male students.

Course content

Barbara admits she did not have a huge *"hands-on understanding"* of mechanical engineering but she could *"learn off most of her work"*. She thinks male students had a greater interest in the lab work. She enjoyed the 9am-5pm structure of the engineering courses.

Male culture

She believes she always *"got on better with men than women"* so she enjoyed the culture of engineering. She defines this culture as *'boozy/slag each other off'*. She felt she used her gender to her advantage *"playing the dumb blonde"*" to her male students so they would help her out with lab work. She did not lose respect from the male students because she managed to attain higher grades than them. She had to *"deal with the laddish talk"* and thought that *"any girl who was easily offended probably wouldn't survive the four years of engineering"*.

Relationship with other Female Engineering Students

She had one close female friend, a *"blokey type of girl"*, defined as one who *"she had a point to prove"*. Some girls tried very hard *"not to be feminine"* or to be *"one of the boys"* or had a *"chip on their shoulder"*. She felt that those who had a 'chip' were trying to bring up an issue that wasn't there.

7.4.4 Why Barbara Never Worked as an Engineer

Barbara never planned to be an engineer since there is *"not enough innovation"* in engineering. Her ideal job would be 'financial engineering'. She thinks that it is very difficult to find degree level jobs in mechanical engineering. Even though she will never work as an engineer, she has no regrets having studied engineering. She thinks the benefit of the degree is that it teaches *"problem-solving"*. She has transferred these skills onto other areas, such as finance.

7.4.5 Debunk the Myth: What further actions can be taken?

- Parents, schools, universities and government should be debunking the myth that *"only men make good engineers"*.
- Parents need to encourage their children in whatever career choice the children make. Parents should keep an open mind to non-traditional careers. They should note that if their child has an aptitude to maths, to suggest engineering.
- Schools should offer more information on 'what' engineers do. Schools should offer a talk *'A Day in the Life of an Engineer'*. Undergraduate students should be giving talks at schools as secondary school students relate better to those closer in age to them.

7.5 Case Study of the Academic Engineer, Christine*

7.5.1 Family Background and Education

The academic engineer, Christine, is in her late 30s and was educated at an all-girls convent school. Her father was a farmer who worked at home and her mother was a chef.

At school Christine enjoyed maths. She did honours maths for the Junior Certificate but did not get a good enough grade to continue honours maths for her Leaving Certificate. She sat Ordinary Level maths for her Leaving Certificate. Her DATS aptitude tests that she sat in her guidance counselling class indicated that she had good mathematical ability and spatial visualisation. Even though she studied Ordinary Level maths, she did feel she had an aptitude for the subject.

She chose to study engineering, having heard about it from the Institute of Engineering of Ireland (IEI) from a major promotion of engineering during the mid 1980s (newspapers). She completed a preliminary engineering course before starting her degree at Bolton Street. This was to facilitate those who did not study Honours maths. She began her degree in 1988. The ratio was 8 female students: 100 male students. She studied mechanical engineering and graduated in 1992, subsequently taking a taught Masters degree in Environmental Engineering. Christine also began lecturing after working in industry for a year before qualifying for a lecturing position.

7.5.2 Role-Models and Influences

Both of her parents wanted Christine to go to third-level education and were supportive of her career choice. Her uncle works in academia as an engineer. She had exposure to academic engineering by going on a tour around a Higher Institution of Education. Christine felt she was influenced by enjoying machines, bikes, motors and clutches and had exposure to these on the home farm.

7.5.3 Career Development and Promotion;

Christine explained that *"women were told that they had to wear skirts"* in the company she worked. Some women did object to this. At presentations, she was expected to bring in tea/coffee even though she was as qualified as the male engineers.

7.5.4 Work-Life Balance

Since having a child, she feels *"split between her child and work"*. She only works on projects that she is interested in and that have *"added value"* by her. Her husband works in academia as an engineer and has been able to take parental leave. The dynamics of the household have changed. She is concerned about the *"lack of knowledge from co-workers about the conditions of parental leave*".

7.5.5 Why Christine is Successful in her Career

She feels that she is very *"tenacious and has great drive"*. She is highly organised which allows her to juggle many things at once.

* The name has been changed to protect anonymity

7.5.6 Culture and Image of Engineering in Academia

Lecturers

In Christine's opinion, some lecturers *"behave funny"* around girls. An example of this is that a lecturer may *"not want girls to work together as they would just talk"*. Some lecturers make innuendos or have said that "*I have to be careful because there are women present"*.

Language

The language of engineering is quite sexual. An example of this would be *"'male part fitting into a female part' followed by a guffaw! from the students"*. Students tend to make comments surrounding this language. There were also often *"explicit jokes"* told by the male students. Christine found the *"pornographic magazines to be the most offensive"* manifestation of this.

Interests

There are three distinct groups in engineering – boys interested in soccer, boys interested in rugby (separated by what school you went to) and boys interested in Formula One racing. She had nothing in common with most boys so she had nothing to talk about though Christine became interested in Formula One racing in order to make conversation.

7.5.7 Debunk the Myth What further actions can be taken?

- Parents should try and understand what engineering is and is not. It is not just mechanical with a man in overalls, dirty or a woman wearing a hard hat.
- Guidance counsellors background is not usually scientific hence physics, chemistry and maths teachers should be targeted to promote engineering. Schools need to realise that engineering is not a science.
- Universities should have a defined Equality Statement/Policy, which will make all staff, and students become aware of how women are treated. The language of engineering needs to be addressed to be more gender non-specific.
- Christine would like to see statistics from the Department of Education and Science on where women in their 30s with engineering degrees are now. She would like to see one central resource centre to include information and data for universities, schools and students.

7.5.8 Other comments

Christine feels that engineering is essentially *"about problem-solving"*. She would love to see a *"mediocre female engineering student"* because in her experience all the female engineering role-models have been high achievers. She thinks it is *"not fair to encourage girls into engineering at the moment because it is a discriminatory environment, has a gender pay gap and offers no support for women"*.

7.6 Case Study of the Site Engineer, Deirdre*

7.6.1 Family Background and Education

The site engineer, Deirdre, is in her mid-30s and was educated at an all-girls school. Her father is a civil engineer and her brother is also an engineer. Of her two sisters, works in business and the other as a doctor.

* The name has been changed to protect anonymity

At school, she took Higher Level maths and science. She had a real interest in maths and science and she felt it would be easy to get a job if she chose engineering. She did not want to study pure science as she thought it would lead to her becoming a science teacher. She did not choose the financial sector (accounting) because it did not include science. She chose engineering after first eliminating all other options.

She attended a Dublin University to study mechanical engineering. After qualifying, she originally wanted to work for a year and then return to academia to do a PhD. She was offered work in UK but did not want to emigrate so chose to work in the public sector. She has been with the same company since 1990.

7.6.2 Role-Models and Influences

She had no specific role models when she was choosing her career. She did feel though that her father, in particular, wanted her to earn a degree.

7.6.3 Career Development and Promotion; Work-Life Balance

Deirdre's career advanced in a 'sideways' manner for many years. She moved around sites quite frequently, more than other engineers within the company. Her employer offered her the opportunity to study for a Masters course, which she agreed to.

Deirdre's husband is also an engineer and she has three children. She did not find working with one child to be particularly difficult. She began to work flexitime (8am-4pm) and had a childminder. She was offered a promotion after her second child but she declined it as she felt she "*could not put in the hours expected of her for a managerial role*".

Deirdre changed career direction for a few months and moved into marketing, which was office based. She felt it would be "*easier to balance work and three children in this area*". She spent less time commuting. She did not enjoy the type of work as she felt it was "*not challenging enough*". She found it "*strange*" working with women as she has always studied/worked with men. She has since moved out of marketing.

Deirdre now works longer than her official hours. Her husband is on study leave at the moment so he manages *"both ends of the da"'* with the children. She does not know what she will do when his course is over. Deirdre thinks that if a female worker is on flexi-time, employers assume that she is *"off the career track"* until she starts working full-time again. She has noted that there are not many part-time jobs available in the profession of engineering. It is too difficult to just *"keep your hand in"* and a *"manager needs to be visible, on-site"*.

7.6.4 Culture and Image of Engineering at University and the Public Sector

There were three types of people, according to Deirdre, at the University she attended – "*female, male, and female engineers!*". She felt that male students "*acted differently to other women who were not studying engineering*".

Engineering is a "*boys culture*" and the environment was "*very technical, logical, no sentiment, persuasive arguments, investigating*". The conversations were different to what she had been used to,

usually "*not very emotional or gossipy*". She felt that the women in her class had a civilising effect on men, especially when the male students used "*coarse language*".

She has not noticed any problems from male engineers in the public sector. She thinks that the image of engineering is still seen as "*tougher, male, dirty*", recognising that there are a lot of women scientists but very few women engineers.

7.6.5 Debunk the Myth What further actions can be done?

Parents should support a child if they have an aptitude or interest in maths or science.
Teachers need to be careful of their personal opinions about honours maths, which is a pre-requisite for engineering. Often, teachers are heard to say in front of the children 'isn't honours maths very difficult?'. This dissuades a child from studying honours maths.
She feels that it is too late for universities to tackle the problem of trying to encourage girls into engineering. One needs to look at 11-12 year olds and promote maths, science and engineering to this age group.

7.7 Conclusions

7.7.1 Family Background and Education

All participants attended single sex schools, loved maths, science and mainly studied at Higher Level maths in the Leaving Certificate. Transition Year work experience played a pivotal role in encouraging or discouraging girls into profession. None of the participants actually thought of engineering as their first career choice. Most mentioned that they eliminated every other career choice before settling on engineering. All were highly qualified with Masters and/or professional studies.

7.7.2 Role-Models and Influences

Maths or science teachers were named as strong positive role-models in encouraging interviewees to study engineering. Parents were not encouragers or discouragers generally supportive of each participant and their career choice. Guidance counsellors were not seen as informative with some participants mentioning that *"guidance counsellors need to learn what an engineer does"*. Some of the participants had knowledge of engineering through family members. Only one mentioned that she loved to 'tinker' with engines and other 'toys'.

7.7.3 Career Development, Promotion and Work-Life Balance

Each of the women (excluding Barbara, the former engineer) are highly successful in their chosen field of engineering. Each has been promoted extensively. All participants are aware of the issue regarding flexitime and how it may negatively affect one's career progression. Amy, the consulting engineer, is very glad to have been promoted already to a high level before having children. There appears to be a general consensus that there is a lack of knowledge about the conditions associated with flexitime. These conditions include reduced hours but also reduced pay and pension issues. All practising engineers work longer hours than they are employed for but feel it is expected within the industry.

7.7.4 The University Culture and Image of Engineering

The culture of engineering at university was defined by the participants as *"male; laddish talk; coarse language; 9-5pm work load; boozy environment"*. The participants found that male engineering undergraduates tended to talk about *"things"* so the environment was rather technical and logical. It was not an emotive culture and there was very little gossip. Among the '*things*' discussed was sport.

The professional engineering environment is less laddish. The image of engineering is still seen as *"mechanical with a man in overalls, dirty or a woman wearing a hard hat"*. Participants feel that the profession is still seen as *"one up from the tradesmen"* and that there is a distinct lack of knowledge by the general public as to what an engineer does.

This lack of knowledge about the actual day-to-day activities of an engineer was seen to be mainly due to the fact that there are now so many different, elite branches of engineering yet are still named under the generic term 'engineering'. They agree that parents, schools, guidance counsellors and students do not know what an engineer does.

All participants used the term *"problem-solver"* to describe an engineer.

7.7.5 Debunk the Myth: Further Actions

Parents

Participants believe that parents need to encourage and support their children if they show a natural ability or love of maths and science. Parents should be open to the idea of a child pursing a non-traditional career path.

Schools

Participants agree that schools need to be informed as to what a 9-5 day of an engineer is like by having an undergraduate engineer come into to talk about college life would have more impact than a qualified engineer because the students would be able to relate better to someone closer to their age. The participants also felt that guidance counsellors need to understand what an engineer does. Some consider the maths/science teacher to be a better role-model (encourager towards engineering).

Universities

Universities need to continue promoting engineering for female students. They should have a defined Equality Statement, which will make all staff, and students, aware of how women are treated. The language of engineering needs to be addressed to be more gender non-specific.

Government

One participant would like to see one central resource centre created to include information and data for universities, schools and students.

7.8 Conclusions

The interviews conducted with four women who had studied engineering explored: family background and education, role-models and influences, career development and promotion; work-life balance; and the culture/image of engineering

- All interviewees had attended girls-only schools and had loved maths and science. Transition Year work experience played a pivotal role in considering engineering as a career. None of the participants picked engineering as their first career choice. All were very highly qualified with Masters degrees and/or professional qualifications.
- Maths or science teachers were identified as providing highly positive role-models who encouraged them to study engineering. Guidance counsellors were not seen as well informed about engineering. Some of the participants had knowledge of engineering through family members.
- Each of the women are highly successful in their chosen field. All participants are aware of the issue regarding flexible working arrangements and how these might affect an employee's career progression. All practising engineers work longer than standard hours but feel it is expected within the industry.
- The culture of engineering at university was defined by the participants as *"male; laddish talk; coarse language; boozy environment"*. The environment was technical and logical, lacking any emotional culture and there was very little gossip.
- Even after graduation, the professional engineering environment is still viewed as '*laddish*'. The image of engineering is seen as *"mechanical with a man in overalls, dirty or a woman wearing a hard hat"* and *"one up from the tradesmen"*. There is a distinct lack of knowledge by the general public as to what an engineer does. This lack of knowledge about the actual day-to-day activities of an engineer was seen to be mainly due to the fact that there are now so many different, elite branches under the generic term 'engineering'.

8. Best Practice Models

8.1 Introduction

The earlier sections of this report have indicated that there are significant differences in the entry and participation rates of women and men in engineering courses, leading to severe under-representation of women in the engineering professions. This does not appear to be accounted for by poor leaving certificate examination performance. While in the 1980s, girls were less likely to have studied Higher Level Leaving Certificate maths, this pattern is not evident for 2002/3. Irish data indicate that female school leavers account for 46 per cent of pupils taking Higher Level mathematics and 47 per cent of those who achieve a 'C' grade. This points to influence of other wider societal factors influencing girls' career choices.

Evidence from other parts of the study, in particular through qualitative approaches such as open-ended questions, focus groups and interviews, point to a number of barriers currently limiting female pupils' entry into engineering. These can be attributed to:

- Few visible role models and mentors;
- Problems relating to the teaching of science and technology;
- Poor understanding of the engineering profession;
- Gender stereotyping of careers advice;
- Lack of knowledge and experience for girls in non-traditional areas of work;
- The 'chilly climate' and culture of engineering.

This section of the study reviews the type and range of measures that have been introduced to at encourage greater participation of women in engineering courses.

8.2 Approach to Review of Measures

Findings, outlined in earlier sections of this report, point to the need for measures at different levels of the education cycle in order to encourage greater recruitment of female pupils into engineering. These suggest the need for interventions at the following levels:

- Primary;,
- post-primary;
- tertiary; and
- in industry.

While scientifically evaluated research on the effectiveness of each of these measures is desirable, such evidence is limited or non-existent. In the absence of formally evaluated research on specific measures, the effectiveness of the interventions have been assessed in terms of the extent to which they have continued to be used, adapted and/or extended by each of the education levels. Hence, the measures are assessed in terms of:

- Have they been tried?

- Have they been replicated/extended?
- Have they been found to contribute to raising women's participation in engineering?

Overall, the research findings point to the need for an integrated holistic approach, recognising the benefit of interventions and partnerships from education, government and industry.

As indicated, there has been very little formal action to raise women's participation in engineering within Ireland. The examples of good practices interventions are most notably from United Kingdom. The education system across the United States is not similar to the Irish education system so examples of best practices are not being taken from this area.

Many of these initiatives have been tried to date with the objective of achieving gender equality. Whilst it would be preferable to review measures that have not only been adopted but evaluated scientifically, such ideal and academically rigorous examples do not generally exist.

8.3 Primary School Interventions

Enthusiastic and inspirational science teaching promotes positive attitudes towards science. Most primary teachers have few science qualifications, and are therefore likely to lack confidence in teaching science. In recent years, OFSTED (Office for Standards in Education) reports and children's test results show that primary school science teaching has improved, owing, at least in part, to programmes of **in-service training** offered by local education authorities, learned science societies and other organisations.

The Women in Science and Engineering (WISE) campaign in UK has produced a poster campaign called 'Flying High'. This is a poster set and teacher's notes, aimed at primary school girls, to illustrate that women can succeed in engineering.

BAE SYSTEMS have produced a CD Rom based resource for primary school teachers and pupils called Primary Engineer. It contains a series of interactive projects with full support materials.

8.3.1 Science Curriculum at Primary School

Gender stereotypes are easily maintained if pupils do not have access to any science subjects. It is recommended that a primary school science curriculum should be set up to teach pupils science at an early age. Ireland is unique in having little or no science taught at primary level (JOC, 2000). Science was first introduced to the Irish primary curriculum in 1900 but was eliminated in 1934 to make room for compulsory Irish. Even with the re-introduction of science into primary education some pupils will be exposed to the minimum requirement o one hour of science per week.

Since the introduction of a compulsory UK **National Curriculum** in 1988, *all* students follow a broad and balanced science curriculum between the ages of five and sixteen. Children's test results at seven, eleven and fourteen years show that girls generally perform as well as, or better than, boys in science and mathematics. (DfEE 2000).

8.4 Lack of Exposure to Engineering

Girls tend to have lower self-confidence when it comes to their perceived ability in performing well some science subjects. It is difficult to persuade girls that they can achieve success in science subjects such as physics when this theme often goes against what they have heard at school, home, by friends and the media.

The need to increase awareness of opportunities in engineering before girls make Leaving Certificate (or UK equivalent) subject choices was recognised by WISE UK. WISE Outlook Programme is targeted at 13-14 year old girls, in any form of post primary school, with practical experience of engineering project work. The practical work is supplemented by a visit to a company which demonstrates the applications of engineering in an interesting and exciting way. The objective of the Programme is for girls to gain hands-on experience of engineering, practice engineering techniques and meet role-models. There are currently 30 colleges who run the 3-day WISE Outlook Programme. WISE have published a best-practice manual 'WISE Outlook Handbook' targeted at colleges.

8.5 The Image of Engineering

The image of engineering is seen to be quite poor and many pupils still consider engineers to 'work on building sites and wear hard hats'. The image of the profession needs to be promoted in a positive manner through the use of media, industry, the engineering profession and the engineering education.

There has been many publications and brochures produced specifically aimed at showing girls that engineering is not just about 'building sites'. Examples of such publications include:

- A video for science teachers, 'Getting Girls into SET', is available from the OST's Promoting Women in SET Unit, in the UK.
- Another video, *Wise Up!*, shows teenage girls the excitement of engineering through interviews with women scientists and engineers working and studying in Wales.

8.6 Women in Engineering Advisor at Third-Level

In the USA (Goodman 2002, IEEE 2004), Canada (Canadian Coalition of Women in Engineering 2004, Zywno 2000) and Australasia (Sivaswamy 1996, Evening 2002), many universities have a Women in Engineering Programme at Third-Level.

WISE Role in the University of Auckland, New Zealand (Evening 2002)
The office of the WISE equity advisor was established in the University of Auckland in 1989. The WISE programmes currently undertaken at the University of Auckland include:

Enginuity Day:
This is an annual one-day programme for senior post-primary schoolgirls held in the Faculty of Engineering. It aims to provide girls with an overview of the Universities engineering programmes and expose them to a variety of engineering career options though the eyes of career role models. The

programme consists of multi-level career talks by women engineers in industry, lecturers, and female engineering students. There are also hands-on activities from all engineering disciplines.

Publications/WISE website:
Several publications have been produced and distributed in schools to raise awareness amongst secondary school girls and their teachers of the services provided by the WISE office and the career opportunities in engineering. The publications include brochures and posters featuring successful role-models.

Regional Shows/Careers Expos
The WISE advisor and selected female students travel to schools in different areas of the country and speak to secondary girls about careers in engineering. The WISE advisor also holds career expos targeted at parents.

Other possible best practices include:

- Summer Camps
- Training lecturers in equality issues (Engineering a Future for Women)
- Changing of the Curriculum.

8.7 Role Models, Mentoring and Networking for Women in Engineering

8.7.1 Need for Role Models

By having so few female engineers that female pupils can associate themselves with, girls seldom identify themselves with the engineering profession. Many researchers stress the need for female pupils to have a prominent engineering role-model in their lives (Cuny 2001, Davis et al. 1996, Mawasha 2000). Blaisdell's research suggest that to increase the likelihood of a high school student planning on an engineering career, efforts need to be focused on the student gaining quality maths and science experience and exposure to engineering role-models (Blaisdell 1998). Mawasha et al. suggest that teachers can learn to be positive role models by encouraging collaborative work and encouraging female pupils' self-confidence (Mawasha 2000).

8.7.2 Role Models Initiative in United Kingdom & Europe

The European Database of Women Experts in Science, Engineering and Technology (SET) was originally developed in 1997 as the first initiative of its kind in Europe to be used to raise awareness of the skills and knowledge in SET.

The UK Department of Trade and Industry provided funding for Women in Science, Engineering & Technology (WITEC) to update the database in order to ensure that it continues to be a valuable tool for the media, governmental bodies such as the EU, school teachers and others who are keen to locate and refer to women who are respected figures in their fields for their views, experience, expertise, and as role models for society (Women in Science).

Through interviewing guidance counsellors, feedback from the survey and case studies of female engineers, it appears that promoting ‘normal and average’ engineers as role-models is more important than just the female ‘successful, high-flyer’ engineers. Since maths and physics teachers in Ireland

tend to be mainly men, this leaves female students subconsciously believing that maths/physics is difficult and only for men.
The obvious policy response is toolicy: Ensure girls are taught by female science and maths teachers, as they are a subconscious female role-model

8.7.3 Mentor Models

Women who establish successful engineering careers, almost without exception, have had important mentors to encouraged them, provide advice and steer them through the early stages of their career. Mentoring for young women is important because girls often make decisions relating to their career by being able to 'see themselves' in the role. Mentoring can be more successful than role-models because it allows pupils at schools to have direct access and attention of a female engineer, compared to reading about one. Mentoring can exist through female engineering students and recently qualified engineers going to schools to talk about their career and progress. It is suggested that post-primary students prefer speakers to be 'close to the age' of the pupils because it is easier for the pupils to relate to the speaker. Many researchers have documented that mentoring is an important initiative in attracting girls into engineering (Lane 2003, Peters et al. 2002, Collins 2003) and offer local mentoring networks.

Corporate mentoring programs range from formal to informal. One-to-one mentoring is most often used. Several companies have set up mentoring programs matching individuals by career track and discipline. Very few programs actually train their participants in how to establish and maintain an effective relationship and even fewer evaluate the success of their mentoring against retention and/or job satisfaction.

If mentoring programmes are to be successful, they need to be:

- Supported from the top with adequate resources, management and administrative support;
- A good fit with the culture of the school, higher education institute, or industry;
- Monitored with feedback, outcomes evaluated, and successes celebrated to sustain management interest and keep the issues on their agenda.

8.7.4 Mentoring in Ireland

Mentorlink is a three year project funded by the Equality for Women Measure under the Regional Operational Programmes of the National Development Plan 2000-2006, which has been proposed and developed in the Institute of Technology in Tallaght, Dublin (Sullivan 2003).

Measures and Initiatives currently underway include:

- Mentoring of female school leavers by third-level students;
- Formation of a student network of female engineers (MINERVA);
- Setting up of a structured e-mentoring programme where third level students and recent graduates are mentored by female technicians and engineers in industry;
- Development of a training programme for mentors;
- Research into the experience of women working as technicians and engineers.

Companies in UK involved in mentoring programmes include:

- IBM

- Ford Motor Company
- Pfizer
- Simons Group
- Institution of Civil Engineers
- Lend Lease

8.7.5 Networking Models

Formal and informal networks offer women the opportunity to share experiences and mentor each other. It offers women the feeling of belonging to a larger community and can combat isolation, especially when women are in the minority in engineering (Goodman 2002). The networks also help to inform, encourage and motivate girls and young women to choose scientific subjects. These informal and formal networks of women can provide databases of role models and mentors for individuals and organisations that require them. In Ireland, Women into Technology and Science (WITS) was established to encourage more women into SET and to provide a support network through which members can keep in touch. Similar activities are provided by networks outside Ireland including:

- Portia Web Project (Portiaweb 1998)
- WES Women's Engineering Society
- WISE Women into Science and Engineering
- CCWEST Canadian Coalition of Women in Engineering, Science, Trades and Technology
- WISENET Australia

8.8 Policy and Best Practices at European Level

With engineering entering a 'knowledge-intensive' climate, governments are becoming aware of the necessity to adopt best practices at an international level. A greater community is being created with the aid of the Internet. The need for the engineering community to maintain global communication is vital.

The Helsinki Group

In 1999, the EU Research Council adopted a Resolution on Women and Science inviting Member States (30 countries) to engage in dialogue and exchange views/national policies, taking into account benchmarking and best practice. The mandate of the Helsinki Group is to promote discussion and exchange experiences on measures and policies devised and implemented at local, regional, national and European level to encourage the participation of women in scientific careers and research. It is also charged with providing national and sex-disaggregated statistics and developing gender sensitive indicators in order to monitor the participation of women in European research (Tees 2002).

8.9 Holistic Approaches

There are often local interventions such as scholarships and grants offered to girls entering engineering, women's network groups, informal mentoring, industry and tertiary interventions. Similar interventions exist at national level. A National Resource Centre for Women in Engineering is the central point of advice, information and promotion of gender equality for employers, career professional, academia, women and female pupils (Peters et al. 2002).

8.9.1 JIVE (Joint Intervention)

The JIVE is a partnership of ten organisations in England and Wales, with a further four partners in Europe who have been funded by the European Social Fund from 2002 to 2005 (Ishaq 2004). JIVE partners are undertaking seven areas of activity in order to provide a holistic approach to dealing with the under representation of women in SET. The activities include:

- Learning providers
- Employers
  - JIVE has developed a cultural audit tool (CAT) and staff development training as part of the program of work to enable employers in identifying and addressing the barriers to women entering and remaining in SET industries. The CAT will enable the assessment of the culture and climate in a given company and diversity practices within that company.
- Mentoring
  - The mentoring programme provided by JIVE partners is the largest of its kind for women in engineering, construction and technology in UK in terms of its cross section of women. The programme is based on role model mentoring and offers organisations a sustainable support structure for women in target sectors from pre-recruitment stage through education on to employment.
- Research and Evaluation
  - An evaluator external to the JIVE partnership has been appointed to co-ordinate the overall evaluation of the partnership.
- Mainstreaming
  - As a result of staff development training, all participants are encouraged to form an action plan to enable them to bring about change within their own organisation.

The JIVE model is holistic in tackling many aspects where women face hurdles and taking a joint approach to bring about change. The approach works with women themselves, career professionals, learning providers, employers and policy makers to bring about change.

8.9.2 United Kingdom National Resource Centre (UKRC) for Women in SET

The Centre has been established as part of the government's strategy for overcoming barriers to women's employment in the SET sector. The centre is a central point of advice, information and promotion of gender equality for employers, career professionals, academia, women and girls.

The UK Resource Centre for Women in Science Engineering Technology (UKRC) and the built environment is based in Bradford and is being developed by Bradford College, Sheffield Hallam, Open University and Cambridge University. The UKRC is funded by the DTI for three years (2004-2007).

The mission of the UKRC is to establish a dynamic central hub that provides accessible, high quality information and advisory services to employers (including academia and the research councils), professional bodies, Sector Skills Councils, careers professionals and Higher and Further Education to promote best practice in the recruitment, retention and progression of women in SET and the built environment. The Centre will map, coordinate and build on the range of good practice initiatives that

have already been developed in this field by providing a strategic focus for driving forward the UK women and SET agenda.

The strength of the JIVE consortium comes from our established links to the SET industries, academia, research councils and women in SET initiatives. A strong resource base has been established consisting of five teams:

- Employer Liaison
- Business and Finance
- Information and Coordination
- Women Returners and Mentoring
- Marketing and Publicity

The aim of the centre is to increase the participation and position of women in science, engineering, technology and the built environment. The 9 core objectives of the UKRC are:

- Supporting, advising and working with SET employers and professional bodies, sharing good practice
- Developing a recognition scheme for good SET employers
- Sharing good employment practice for women in SET
- Maintaining and disseminating UK gender statistics
- Supporting SET returners
- Raising the profile of Women in SET
- Setting up and running an expert Women in SET database
- Pump priming innovation and providing bursaries for speakers
- Coordinating the work of women in SET organisations

Another form of a central hub of information is the **Directory of Initiatives** published by the WISE Campaign. The Directory is specifically targeted at for women in SET. This directory is published and updated annually listing details of:

- Sponsorships;
- Awards;
- Competitions;
- Courses;
- Visits;
- Women in engineering websites;
- Company family-friendly policies;
- Other initiatives designed to encourage girls and women to consider careers in SET.

The Directory can be downloaded from the WISE website.

9. Conclusions and Policy Recommendations

9.1 Conclusions

9.1.1 Statistical Review

- The proportion of women in engineering occupations remains significantly lower than that for men with women engineers accounting for 3,837, or 11%, of engineering professionals and technicians in 2002. The younger age profile of women engineers suggests that they should comprise an increasing number and percentage of future engineering students/graduates and professionals in Ireland.

- Among US engineering degree holders female representation rose from less than 1 per cent in 1966 to 20 per cent in 2001. Hence the current level of female engineering graduates (9%) in Ireland is *comparable to that prevailing in the US in 1979.*

- While female students accounted for 58 per cent of *all* full-time undergraduate enrolments in the academic year 2002/3 only 19 per cent of engineering graduates were female. This level contrasts sharply with the high level of female representation in social science, education, arts, law, medicine, science and business/economic and social studies in which women comprise the majority of students.

- The most common entry requirement for engineering at third level is a 'C' in higher-level or better. Female pupils accounted for 46 per cent of those taking higher level mathematics at Leaving Certificate level. Of the boys 73 per cent achieved a grade of C or better compared with 77 per cent girls.

- Based on Leaving Certificate performance there is no evidence that lack of academic achievement, notably in Higher Level mathematic, can explain the low level of female entry to engineering studies at tertiary level. The analysis suggests that strategies aimed at raising the number of women in engineering education/occupations need to focus identifying the barriers that discourage them.

9.1.2 Literature Review

- No previous national study of the under-representation of girls in engineering has been undertaken in Ireland. It is long overdue, given the small proportion of women entering into engineering. Three main reasons why an increase in the participation of women in engineering is necessary concentrate on:

    - gender parity or equality;
    - the changing nature of engineering and
    - the shift towards a knowledge intensive society.

- Despite the evident deficit of women in engineering professions/courses, research studies that focus *exclusively* on the factors that hinder female secondary schools from choosing engineering are scarce. Much research looks at factors that encourage

female students to stay in engineering or science once they are studying at third-level. Such retention factors include positive images of scientists and engineers, support of women's equality, and positive classroom experiences. Other research has investigated the educational climate/culture for women studying in predominantly male engineering courses, with a view to suggesting strategies to combat any difficulties female students may encounter.

- Researchers have explored the issue of self-efficacy, defined as the self-perception of a student's ability to learn engineering against the student's actual ability to learn in engineering. Measures to increase female students' self-efficacy within engineering include collaborative learning practices to allow 'critical thinking'.
- The secondary level maths and science curricula may discourage female students from considering engineering at third level due to the current emphasis on 'chalk and talk' blackboard culture in stark contrast with more experimental methods that emphasise problem-solving skills and 'learning by doing'. Other research highlights textbook bias where men are pictured more often than women and shown in more active roles.
- Classroom experience may affect girls where they receive less attention than boys in the science classes and are encouraged by their teachers to study subjects that would be more suited to their gender. Teachers' decisions on which level a student should study a subject (e.g. Ordinary or Higher) are often based on 'affective factors' such as: the teacher's own attitude to subjects; the perceived ability of the students; confidence or anxiety with the subjects.
- Some literature stresses that the role of guidance counsellors is influential in guiding pupils in their career decisions. The role of the parent is seen as important in providing young girls with out-of-school experience and integrating their classroom lessons with extracurricular activities. Male children tend to get more early extracurricular activities that develop mechanical inquisitiveness and problem-solving skills while female children typically have fewer play experiences that build spatial and physical concepts. Girls' play experiences tend to be stationary, stimulating very little interest in the physical laws of nature.
- The lack of role models of women in engineering occupations/studies has been identified as a factor that may inhibit the interest and careers of girls at secondary schools.

9.1.3 Role of Guidance Counsellors

A survey of guidance counsellors in secondary schools in Ireland indicates that:

- Girls choose engineering because of the 'academic ability/intellectual challenge' while boys choose it because of the 'earning potential' and that girls lack 'role models'. The role of father is seen to be the most influential to both male and female pupils' career decisions while maths and science teachers also exert a strong influence. The majority feel that 'common entry' into engineering is a better option for all students.

- Schools have very little direct contact from engineering firms yet higher education institutions and STEPS contacted 4 out of 5 guidance counsellors. Respondents felt

the need for specific actions to be adopted by industry, higher education institutions and engineering initiatives in order to interest female pupils in engineering. Specific actions include:

  - Having school talks about engineering by women engineers from industry, women engineering students and women engineering lecturers;
  - Establishing a mentorship system between female pupils, industry, higher education institutes and engineering initiatives;
  - Describing profiles of women engineers, which allow students to learn what an engineer does.

- Guidance counsellors believe parents could inform themselves of the exact job role of engineers; understand the benefit of engineering to the community; and illustrate this benefit to their children. They would like parents to view engineering as a non-gender specific career; be informed on the image they should be portraying; and encourage their daughters to pursue higher-level maths and physical sciences.

- The promotional materials issued to schools to encourage more girls to consider engineering include videos, handouts, poster campaigns and visits by speakers to schools. Guidance counsellors believe that a three-way partnership between schools, higher education institutions and industry would be effective in encouraging female pupils. They suggest the introduction of 'gender specific' seminars for female pupils and felt that all teachers need to demonstrate positive attitudes to engineering during science class and careers class. They also felt the need for higher education institutions to provide clear explanations as to what each discipline of engineering does, by explaining in laypersons' terms.

- Guidance counsellors specifically seek the following:
  - Improved ratio of guidance counsellors to pupils;
  - Access by pupils to talks and presentations;
  - All subjects open to female pupils;
  - Awareness and support for equal opportunities;
  - Promotion of role models (e.g. past pupils);
  - Speakers from/visits to firms;
  - Use of aptitude tests early on to identify aptitudinals;
  - Encouragement for girls to study higher-level maths and physics.

9.1.4 Views of Leaving Certificate Pupils

A large scale survey of male and female Leaving Certificate pupils showed the following:

- Significantly fewer female pupils are studying higher-level maths (19%) compared with 28 per cent of male pupils. They believe that both higher-level maths and physics are pre-requisites for studying engineering at third level.
- While half the male pupils considered engineering as a career only one in ten female pupils considered engineering. If offered a place on an engineering course, one

quarter of male pupils would accept while only three per cent of female pupils would do the same.

- Boys are deterred from applying to study engineering because they feel they are better at other subjects; do not have the pre-requisite subjects; and have no interest or knowledge about engineering. Girls are deterred from applying because they believe engineering is 'only for males'; they are better at other subjects; have had poor career advice about engineering; do not have the pre-requisite subjects; and have little interest in, or knowledge about, the profession.
- Both male and female pupils consider their fathers to be the most influential person in their consideration of a career in engineering, followed by guidance counsellors and then their mothers. More than half of male and female pupils agree that: one '*does not have to be really clever to study engineerin*g'; '*engineers do need to know about environmental issue*s'; and '*it would be easy to get a job if studying engineerin*g'.
- The majority of male and female pupils agree that: '*engineers are not considered nerds at schoo*l'; '*engineering is a creative profession*'; and '*engineers are well paid*'.
- Significantly more female pupils agree that '*there should be more female engineers*' compared with male pupils and significantly more female pupils disagree that: '*only men make good engineers*'; and '*a female engineer needs to act like one of the boys to perform well in her job'*, compared with male pupils. However positively pupils view engineering, girls still do not feel it would be '*exciting'* to do engineering.
- There is evidence among second level pupils of adherence to strong gender-stereotypes for certain occupational roles. Electricians, train drivers and engineers are perceived to be jobs for 'men only' compared with primary school teacher and nurse which are seen as 'women only' jobs. Male pupils appear to have more fixed and gender-stereotyped ideas about the suitability of traditionally 'male' and 'female' professions.
- Male pupils have much greater exposure to 'tinkering' and engineering type tasks prior to entering third level than female pupils, including fixing something mechanical or electrical. Both male and female pupils are more likely to know a male, rather than a female, engineer which reinforces the claim that there are fewer women role models for female pupils.

9.1.5 Focus Group Discussions among Secondary Pupils

Three Focus Groups were undertaken in all-boy, all-girl and co-educational schools in Dublin. These discussions highlighted the following:

- The general consensus by all pupils is that Higher-level maths is a definite requirement to study engineering at a higher education institution. In choosing subjects to study at school, boys believe that girls *"listen more to their friends whereas guys' mates would not influence their subject choice"*. Girls agreed that their female friends are the main source of discouragement from studying engineering for the Leaving Certificate. *"Our friends turn us off doing it"* by saying, "*why would you want to do engineering?"*. They felt that girls being in the minority in class might feel intimidated and isolated.

- Having a *"female engineering teacher"* would be a positive influence for girls. She would act as a *"role-model"* and demonstrate that *"[Engineering] may not be just a guy's thing"*. All female participants agreed that the word *"man"* was present when they thought of 'engineer' and admitted that this could subconsciously influence their decision to choose engineering.
- Some male pupils felt that women would make better engineers because, with so few women entering the profession, those who become engineers are more *"driven"* than men. A male student believed that women are *"harder workers yet they do think differently to men"*. One student felt *"guys go into engineering by default"*.
- The majority of female pupils consider that women would have to work harder to impress, and to get respect from, men in the engineering profession. Female focus group participants believe that even where men and women are in the same profession, *"a man would get a better job because sexism will always exist"*. One female participant had a positive attitude to engineering and felt that all women definitely could do be engineers but when asked why she did not choose it said *"it isn't for me"*.

9.1.6 Career Trajectories of Female Engineering Graduates

One-to-one interviews were conducted with four contrasting female engineering graduates to obtain information on their career aspirations, motivations for studying engineering and their subsequent experiences in third level and the labour market. The interviews were semi-structured to capture information under the following headings: family background and education, role-models and influences, career development and promotion; work-life balance; and the culture/image of engineering

- All interviewees had attended girls-only schools. They loved maths, science and all but one studied had Higher Level maths for their Leaving Certificate. Transition Year work experience played a pivotal role in considering engineering as a career. None of the participants picked engineering as their first career choice. Most mentioned that they eliminated every other career option before settling on engineering. All were very highly qualified with Masters degrees and/or professional qualifications.

- Maths or science teachers were identified as providing highly positive role-models who encouraged them to study engineering. Parents were not seen as encouragers or discouragers but they were supportive of participants in their career choices. Guidance counsellors were not seen as well informed about engineering. Some of the participants had knowledge of engineering through family members. Only one mentioned that she had loved to 'tinker' with engines and similar 'toys' s a child.

- Each of the women are successful in their chosen field and have been promoted. All participants are aware of the issue regarding flexitime and how it may affect an employee's career progression. The female consulting engineer is very glad to have been promoted to a high level before having children. There appears to be a general consensus that there is a lack of knowledge about terms and conditions associated with flexitime and working reduced hours, including pay and pension issues. All

practising engineers work longer than standard hours but feel it is expected within the industry.

- The culture of engineering at university was defined by the participants as *"male; laddish talk; coarse language; boozy environment"*. The participants found that male engineering students tended to talk about *"things"* (including sport). The environment was technical and logical, lacking any emotional culture and there was very little gossip.

- Even after graduation, the professional engineering environment is still viewed as 'laddish'. The image of engineering is seen as *"mechanical with a man in overalls, dirty or a woman wearing a hard hat"*. The interviewees feel that the profession is still seen as *"one up from the tradesmen"* and that there is a distinct lack of knowledge by the general public as to what an engineer does.

- This lack of knowledge about the actual day-to-day activities of an engineer was seen to be mainly due to the fact that there are now so many different, elite branches under the generic term 'engineering'.

9.2 Policy Recommendations

Section 9.2 outlines the measures and actions to address the under-representation of women in engineering, particularly within the tertiary education sector.

9.2.1 Establishment of a Task Force on Women into Engineering

Arising from the findings of this study there is a need to put in place an Expert Task Force jointly by the Departments of Education and Science and Enterprise and Employment to work on the issues identified in the statistics, literature and national surveys of guidance teachers and Leaving Certificate pupils in Irish secondary schools. It is clear that if left unaddressed the chronically low levels of female participation in engineering courses, and gender imbalance in engineering occupations, will persist for several decades.

The Task Force should include in its Terms of Reference the need to: address current skill shortages, contribute to economic growth and to a knowledge based society; stress the case for a more diverse engineering workforce; and the need to transform the engineering professions. There is a clear business imperative for tapping the underused pool of female talent emerging from the secondary school system who are currently 'turned off' by the unwelcoming image and reality of engineering.

9.2.2 National Engineering Centre

Modelled on the UK Government response to 'SET Fair: A report from Baroness Greenfield CBE to the Secretary of State for Trade and Industry', an Engineering Resource Centre should be established in Ireland. This Centre's aim would be to provide the infrastructure for women in engineering, organisations involved with engineering, networks and engineering initiatives. Such a Centre would need to minimise replication of activities and act as the main

focus for the media, government, academia, industry and professional societies. The Centre would seek to raise the profile of women in engineering at all stages of entry by providing the following:

- An 'Expert Women's' Database;
- Good Practice Guides for higher education institutions and industry;
- Collection, maintenance and monitoring of gender disaggregated statistics on women in engineering;
- Funding support for mentoring and networking among women at all stages of engineering education/employment;
- Compilation of local and national directories on women in engineering at all levels;
- Creation and maintenance of. an Internet site that interested parties can access.

9.2.3 National Media Campaign

Working with the Centre's infrastructure and Institution of Engineers of Ireland there is the need for an information campaign to influence the attitudes of the general public, and particularly school children, parents and teachers at all levels about engineering and the actual and potential role that girls/women can have as engineering professions and technicians. This would need to stress the diversity and creative aspects of engineering and how what is done by engineers impacts on everyone's daily life. Most particularly the 'hard hat', 'dirty' and 'mechanical' image need to be addressed to show alternatives. Such media campaigns have been instituted for recruitment to the armed forces and other gender stereotyped jobs like social work.

9.2.4 Primary Level Intervention

Given the gendered and uneven exposure of girls, compared with boys, to technical/mechanical items, there is a need to incorporate a technology module, along with science, into the primary level curriculum. This would include 'life skills' and practical components e.g. safe use and replacement of electrical items that could be undertaken in the classroom by all pupils.

9.2.5 Secondary School Level

- There is a need to implement all the actions identified by the Task Force on the Physical Sciences including:
    - Planning and resources for school sciences
    - Equity of access
    - Teaching and learning of science
    - School curriculum and assessment
    - Promotion of science and careers
    - Science education at third-level.

  Most notably the science and maths curriculum need to reflect 'real life'.

- Within schools, particularly girls-only schools, there is the need for better career advice; information on initiatives; and hands-on exposure to engage more girls to explore engineering education and enter engineering careers.

- Female role models, who have embarked upon successful careers in non-traditional areas like engineering and technology, need to be invited into schools to explain what engineering is about and talk enthusiastically about their profession and opportunities for future female graduates.

- Prizes need to be assigned and awarded to the best female pupils for outstanding performance bye female pupils in subject areas where they are currently under-represented at Leaving Certificate level (i.e. physics, applied maths).

9.2.6 Support to Secondary Schools

Junior Cycle

- Studies suggest that students start to select their career area between the ages of 12-14 years. This coincides with choosing subjects that ultimately impact on subject choice for the Leaving Certificate. Hence Junior cycle is a key time to target girls before they make decisions that could exclude future career options. Individual career education would need to commence in first year to allow relationships to form between pupils and guidance counsellors;
- An Engineering Roadshow, offering practical applications of engineering projects, should be initiated for female students aged 12-15 years.

Transition Year/Senior Cycle

- A scheme should be set up in which Industry offers practical work experience to interested female pupils during transition year;
- This could be linked with or independent of 'work shadowing' a female engineer for a day/week within an organisational setting;
- Engineering Summer Schools in third level institutions with financial assistance/grants for high performers/prospective third level students.

Mentoring

Experience with the Mentorlink project shows that mentoring for young women is important because girls often make decisions relating to their career by being able to 'see themselves' in the role through having direct access to, and attention of, a female engineer. Mentoring can draw in female engineering students and recently qualified engineers going to schools to talk about their career and progress. Such experience and exposure can be advantageous to both parties.

9.2.7 Tertiary Level Education

- Launch of a Good Practice Guide modelled on Scottish Higher Education Funding Council (SHEFC) Athena Project based on experiences in 12 universities, to provide support for female school leavers embarking upon studies in engineering.
- Scholarships for women pursuing degrees in engineering, as a non-traditional area of study.
- Creation of a permanent position of 'Women in Engineering Advisor' for all Engineering Faculties/Schools in higher education institutes, based on experience in New Zealand universities. The job description would include organising engineering-

day programmes in higher education institution targeted at female pupils only. The objective of such as programme would be to provide girls with exposure to a variety of engineering career options though the eyes of engineering role models. Other tasks would involve publication of brochures/pamphlets; visiting schools and organising career exhibitions.

- Mentoring and networking by and behalf of women in third level engineering studies to ensure their retention and adaptation to engineering employment after graduation, modelled on the MINERVA network of female engineering students.
- In view of criticisms concerning the engineering curriculum/teaching methods and the 'laddish' behaviour prevailing in third level engineering courses, gender and diversity training (See 2.8) needs to be introduced in tertiary educational establishments.

9.2.8 Diversity and Awareness

Programmes to promote gender and diversity awareness should be mandatory in all schools, higher education institutes and industry. Diversity training addresses stereotypes and preconceptions, issues of sexual harassment, cultural differences and styles of communication and learning. This type of training is useful for debunking the myths about the unsuitability of women at all stages of engineering. It also ensures that girls/women are not isolated for 'special' training.

9.2.9 Public Recognition and High Visibility for Women

Allied to the media campaign outlined in 2.3 there is the need for on-going recognition of women's actual and potential contribution to rectifying the current imbalance in engineering and portraying women as equal to men, through awards and approvals to individuals, schools, community groups, higher education institutions and industry in recognition of their innovative efforts to increase society's awareness of women in engineering.