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Form, Function or Fiction: Gender and Diversity in Engineering Programmes in Ireland

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INTRODUCTION

Messe agus Pangur Bán,
cechtar nathar fria shaindán:
bíth a menmasam fri seilgg,
mu menma céin im shaincheirdd.

I and Pangur Bán, my cat
'Tis a like task we are at;
Hunting mice is his delight
Hunting words I sit all night.

The poem Pangur Bán [1] was written by an unknown Irish monk in the Benedictine Abbey of Reichenau, in southern Germany in the ninth century. The Abbey, founded in 724 by Saint Pirim, was a centre of learning in Europe for many centuries, reaching its apex under Abbot Berno of Reichenau (1008–48).

The Christian church was the sole focus of education in the first millennium, with centres of learning developing around monasteries (e.g. Cluain Mhic Nóis in 546 [2]). The Christian religion, based on Hebrew and Greek documents translated into Latin,

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required scholarship; at the very least, clergy had to be able to read and write Latin. This was less a problem in Italy, France and other countries with a Latin derived language, but was quite challenging for others. The medieval monastic school was quite diverse, with scholars from all over Europe attending the most prestigious. This was greatly facilitated by the universal use of Latin as a lingua franca. Both monasteries and convents had schools, allowing women an equal, albeit separate, scholarly status. The German Benedictine Abbess, Hildegard von Bingen (1098 – 17 September 1179), is one such example, writing sublime hymns, and producing treatises on such diverse topics as theology, medicine and botany. Hildegard's family were minor nobility, one flaw of the medieval system from the modern point-of-view; men and women could be educated, but only if they were wealthy. [3]

Some of these monastic schools, such as Paris (1150), developed into universities in the late middle ages, but most of Europe's early universities were secular counterparts to the guild system of craft education (e.g. Bologna (1088) and Oxford (1167)). They were seen as a separate community of teachers and students, *universitas magistrorum et scholarium*, from which is derived the English word university. Unfortunately, these secular universities were men only, and would remain so until the late 19th century.

The University of Bologna made its reputation from the teaching of Roman law; all early universities concentrated on a classical education, studying the philosophy of Plato and Aristotle and the literature of Euripedes and Virgil. Even into the 20th Century, many traditional universities prided themselves on the classics, and either ignored or downplayed newer disciplines, especially the sciences. One consequence of this in the late 19th Century was the development of dedicated technical colleges outside the traditional university system. In France, in 1794, the École polytechnique was founded by Monge to achieve the highest standards in Science and Engineering. In Dublin, a similar institution, the Royal College of Science, was established in 1867. In 1926 it was absorbed by University College Dublin (UCD), becoming the faculty of Science and Engineering.

Over the past millennium, most third level education has been rooted in the humanities, specifically in the Greco-Roman tradition. Engineering education was confined to the military and to craft guilds. The Romans pioneered the military use of engineering, with cohorts of engineers to build roads and bridges to move the legions around quickly, and weapons engineers to build siege machines. In medieval times, craft guilds controlled most trades, with young men who wished to become craftsmen having to pay to do an apprenticeship, followed by a number of years as journeymen. To join the guild, the journeyman had to pay a sum of money to the guild, and then produce a masterpiece, before the guild's master craftsmen elected them as full members.

Henry Ford once said, 'History is bunk', going on to muse that it really does not matter how many times the Ancient Greeks flew kites. [4] Does it matter what type of education Europe has had over the past millennium? What relevance does it have today that most of that education was rooted in the classics? Why should we care that Engineering developed outside the mainstream universities?

It matters because what happened in the past conditions the present. In particular, the fact that women's education was confined to the humanities matters today, because there is no tradition of women engineers. Men are part of a tradition going back to the ingenious (Latin *ingeniator*, from which the word engineer derives) men who built roads, bridges and siege machines for the Roman legions; women are not. Even when engineering became a part of university life, it retained much of its origins

in the apprentice system of guild education, specifically time in the workshop. Today, there are many engineering courses where one does not have to spend hours in workshops learning how to use a lathe, or weld mild steel, but the perception is otherwise.

Oner Yurtseven of Purdue [5] makes this point in his 2002 paper, *How Does the Image of Engineering Affect Student Recruitment and Retention? A Perspective from the USA:* "As engineers, we see ourselves as bright, articulate, honest, responsible, conscientious and capable. There will not be any argument against this from an engineer of course. The US public version of our image as engineers is not, however, this complimentary. We are seen as predominantly male, too bright for our own good, honest to a fault, non communicative, dull, and loners."

A second, vital point is relevant from the Middle Ages in Europe: the concentration of education amongst a tiny, clerical elite was too restrictive, and Europe stagnated for a thousand years, until the stimulus of the Renaissance motivated 14th Century Italy. We cannot afford stagnation today simply because our Engineering education is too narrow and confined, in the main, to only section of society.

1 LITERATURE REVIEW

There have been two studies of the low participation of women in Engineering in Ireland in recent years. The first, and most comprehensive is *Danger! Men at Work - A Study of the Underrepresentation of Women in Third Level Engineering*, produced by Dr Eileen Drew and Ms Caroline Roughnen of Trinity College, Dublin in 2004 [6]. Roughnen has also written about the issue with Jane Grimson in *Diversity in engineering: tinkering, tailoring, transforming*? in 2009.

Drew and Roughnen's terms of reference were:

1. Carry out interviews with key informants in the secondary and tertiary education sectors;
2. Undertake a literature review of national and international data, including www sites, to identify:

(i) obstacles to girls entering engineering courses;
(ii) career paths among women engineering graduates and
(iii) best practice models;

3. Analyse existing data sources on engineering professionals, students and applicants to engineers courses of study at third level;
4. Conduct a survey of Careers Guidance Teachers in Irish secondary schools;
5. Carry out a national survey of secondary school female and male pupils to ascertain their knowledge and perceptions of, and interest in, studying engineering
6. Organise Focus Group discussions with potential school leavers;
7. Conduct interviews with women engineers with diverse career paths.

Their recommendations included the setting up of both a Task Force on Women in Engineering and a National Engineering Centre to promote best practice, especially in relation to gender equality.

The second report was produced by the UCD Engineering Graduates Association [7] in 2014, *Towards Gender Balance in Engineering*. The report is in three sections:

1. General research into the representation of women in the Engineering Profession
2. Specific findings in relation to UCD Engineering
3. Recommendations

The conclusions and recommendation of these reports generally falls into a few well, tried, and not-very successful strategies, such as better information, more use of social media to attract teenage girls, more contact with parents and guidance councillors, targeted scholarships to encourage more female engineering students.

The Higher Education Authority, a statutory body which oversees third level education in Ireland produces annual reports.

In the 2015 report, the HEA states that there are 151,300 undergraduates in Irish third level institutes, of whom 16,721, or 11% are studying Engineering, manufacturing and construction. Participation overall was almost exactly 50:50 in terms of gender.

In terms of socioeconomic status, the universities had more of the higher categories and the Institutes of Technology had more of the lower:

Table 1. Socio-Economic Group by Sector 2014/15 and 2013/14

Socio-Economic Group by Sector 2014/15 and 2013/14 [8]				
	Universities		Institutes of Technology & National College of Ireland	
	2014/15	2013/14	2014/15	2013/14
Employers and Managers	18.8%	19.2%	14.1%	13.9%
Higher Professional	13.9%	14.0%	5.8%	4.5%
Lower Professional	9.9%	10.0%	6.6%	5.9%
Non-manual	9.9%	9.5%	10.2%	9.8%
Manual skilled	8.2%	8.4%	12.6%	12.5%
Semi-skilled	4.2%	4.5%	6.8%	6.8%
Unskilled	3.6%	3.4%	6.2%	6.3%
Own account workers	6.9%	6.8%	8.1%	8.2%
Farmers	6.8%	7.0%	6.7%	6.2%
Agricultural workers	0.3%	0.3%	0.6%	0.5%
All others gainfully occupied, and unknown	17.6%	16.9%	22.3%	25.4%

A similar pattern is found in the ethnic background of students, with the children of immigrants more likely to study in Institutes of Technology:

Table 2. Ethnic Group of Respondents 2014/15

Ethnic Group of Respondents 2014/15 [8]			
	Universities	Institutes of Technology	All institutions

Irish	89.0%	85.9%	87.9%
Irish Traveller	0.1%	0.2%	0.2%
Any Other White Background	6.1%	7.7%	6.7%
African	1.2%	2.7%	1.8%
Any Other Black Background	0.1%	0.2%	0.1%
Chinese	0.5%	0.3%	0.4%
Any Other Asian Background	1.3%	1.7%	1.5%
Other	1.5%	1.2%	1.4%

The number of students with a disability entering third level in 2014 was:

Table 3. Respondents with a Disability 2014/15

Respondents with a Disability 2014/15 [8]		
Type of disability	% of respondents	% of new entrants
Blindness, deafness, severe vision or hearing impairment	6.4%	0.5%
Physical Condition	7.8%	0.6%
Specific Learning Difficulty	57.3%	4.6%
Psychological/Emotional Condition	25.1%	2.0%
Other, including Chronic Illness	23.4%	1.9%

The HEA data for gender balance in the sector for 2013 [9] is:

Table 4. HEA data for gender balance in the sector for 2013

Field of Study (ISCED)[1]	Universities				Institutes of Technology				Totals	
	M	F	Total	% Female	M	F	Total	% Female	M	F
Engineering, Manufacturing and Construction	4661	1223	5884	20.79%	3746	579	4325	13.39%	8,407	1,802
(500) Combined Engineering, Manufacturing and Constructi	1088	255	1343	18.99%	92	7	99	7.07%	1,180	262
(520) Combined Engineering & Engineering Trades	913	153	1066	14.35%	179	14	193	7.25%	1,092	167
(521) Mechanics and metal work	517	41	558	7.35%	524	29	553	5.24%	1,041	70
(522) Electricity and energy	12	3	15	20.00%	323	19	342	5.56%	335	22
(523) Electronics and automation	665	116	781	14.85%	424	38	462	8.23%	1,089	154
(524) Chemical and process	201	125	326	38.34%	27	19	46	41.30%	228	144
(525) Motor vehicles, ships and aircraft	54	14	68	20.59%				0.00%	54	14
(540) Combined Manufacturing and Processing	38	2	40	5.00%	10	3	13	23.08%	48	5
(541) Food processing	149	216	365	59.18%	26	72	98	73.47%	175	288
(542) Textiles, clothes, footwear, leather	0	0	0	0.00%				0.00%	-	-
(543) Materials (wood, paper, plastic, glass)	154	7	161	4.35%	84	2	86	2.33%	238	9
(544) Mining and extraction	0	0	0	0.00%				0.00%	-	-
(580) Combined Architecture and building	249	17	266	6.39%	55	11	66	16.67%	304	28
(581) Architecture and town planning	332	210	542	38.75%	803	279	1082	25.79%	1,135	489
(582) Building and civil engineering	289	64	353	18.13%	1199	86	1285	6.69%	1,488	150

As can be seen, the overall percentages are 20.79% female students in the universities and 13.39% in the Institutes of Technology, giving a total of 17.65% across the whole third level sector.

The Central Statistical Office of Ireland produces quarterly labour force reports and five-yearly census reports, the last census being in April 2016.

2 INSTITUTIONAL CONTEXT

2.1 Secondary School

Irish pupils begin secondary school at age 12 and leave at age 18, on average. The first three years are known as the Junior Cycle, which finishes with a state examination, the Junior Certificate. In some respects, this is a remnant from a time when many left school at age 15, or earlier. The Irish government is now trying to exit the cycle, replacing the state exam by in-school assessment. The Junior Certificate is usually followed by Transition Year, a year of alternative learning experiences, although it is not compulsory. Students then do a two year Leaving Certificate programme, which is capped by a State examination, which determines the University courses open to the student. This is done on the basis of points awarded for the six subjects taken. Subjects can be taken at ordinary or Higher level. A bonus of 25 points to whatever points were achieved, was introduced for Higher Level mathematics, in order to improve the low numbers taking the subject at higher level. Note that mathematics is a required subject for the Leaving Certificate. The maximum points available are 600, plus 25 = 625 if higher Mathematics is taken and passed.

Table 5. Irish Leaving Certificate Points

Leaving Certificate Grade	Higher Level Points	Lower Level Points
A1	100	60
A2	90	50
B1	85	45
B2	80	40
B3	75	35
C1	70	30
C2	65	25
C3	60	20
D1	55	15
D2	50	10
D3	45	5

Points for admission to University courses are a function of demand: the more students competing for places, the higher the points. In 2015, Ireland's largest university, UCD Dublin required 500 points for Engineering, but 575 for Veterinary Medicine.

STEM figures for Ireland's school leavers look good, but there are important caveats. Mathematics is a compulsory subject, so it is taken by almost 100% of students, male and female. Health and social sciences at university is the most popular choice for female students, and this is shown by the Science figures. Over ten times as many girls take Biology at Leaving Certificate as Physics (54.2% of all girls sitting the LC versus 4.8% for Physics). [10]. Engineering at LC was taken by 0.6% of girls and 13.5% of boys. No single-sex girls school offers engineering at LC. This then translates to third level where in 2012, 6, 181 males graduated in Engineering, versus 1,092 females (15%). [10]

2.2 The Irish Higher Education Landscape

Ireland has seven traditional universities, ranging from the oldest, Trinity College (TCD, founded in 1592) to the newest, NUI Maynooth University (founded in 1997, although it began life as St. Patrick's Catholic seminary in 1795). Then there are 14 Institutes of Technology, including the Dublin Institute of Technology(DIT), a member of the European Universities Association, with degree awarding powers to doctorate level. There are also small private colleges and other independent colleges. The institutions are publicly funded by the Irish Government via the Higher Education Authority.

Admission to higher education in Ireland is via a Central Admissions Office (CAO), with access to programmes allocated on the basis of points obtained in the State Leaving Certificate examination. Qualifications are graded according to a scheme devised by the National Qualifications Authority of Ireland (NQAI). In this scheme, Level 7 is an Ordinary bachelor degree, Level 8 is an Honours bachelor degree, Level 9 is a master's degree and Level 10 is a doctorate.

2.2.1 Trinity College, University of Dublin

Trinity was founded in 1592 by order of Queen Elizabeth, using land seized by her father from the Cistercian monks. It was intended, and for many years was, a bastion of English and Anglican education. Along with the universities of Cambridge and Oxford, Trinity's library had copyright privileges, with publishers being required to deposit a copy of their book in its library in order to secure copyright.

The School of Engineering in Trinity College Dublin was founded in 1841. Initially, the duration of the engineering course was two years but was extended in 1845 to three and in 1957 to four years. Diplomas were awarded at first and the Degree of 'Baccalaureus in Arte Ingeniaria' (BAI) was instituted in 1872.

On the first day of the new engineering programme, 15th November 1841, Humphrey Lloyd addressed the male students [11]:

"Such, gentlemen are the provisions which the heads of the University have made for your instruction. The profession which you have adopted, whose duties were not long since limited to the construction and care of engines, has now risen to take its rank among the first of the liberal professions. In a country like ours, where public works of such magnitude are ever in progress the interests committed to its keeping are numerous and weighty; and the knowledge demanded of it proportionally varied and extensive. It is your part, then, to try to profit by the opportunities thrown open to you. Attend with diligence to the instruction which will be given to you within these halls; take full notes of what you hear; and endeavour to combine the knowledge thus gained with the results of your private reading. You have every inducement that can be offered to exertion. The path which is to conduct you to the goal of your profession

is an interesting and attractive one; and the career which afterwards expands before you, is one in which you may serve your country nobly, and earn for yourselves an honourable independence, and an honourable fame."

It would be 1904 before women students were admitted to Trinity. Today, women account for 42% of undergraduates.

2.2.2 The National University of Ireland (NUI)

The NUI was set up in 1908 by Royal Charter. It was composed of University College Dublin (UCD), University College Cork (UCC) and University College Galway (now NUI Galway). UCD began life in 1854 as the Catholic University, with Cardinal Newman as its first Rector. UCC and NUIG began in 1849 as the Queen's Colleges, along with Belfast, which still retains the name.

NUI Galway has a special role in the history of women in engineering as Alice Perry graduated from there in 1906 with a degree in Civil Engineering, the first woman engineering graduate in Ireland or indeed Europe. Her father, who was County Surveyor (now Engineer) in Galway died shortly after her graduation, and she replaced him on a temporary basis for six months. This made her the first, and sadly, so far, the only female County Engineer in Ireland. [12]

The proportion of female engineering students in the NUI has been fairly constant at around 20%, despite many initiatives to increase this figure.

2.2.3 The Dublin Institute of Technology (DIT)

Although the DIT only legally began in 1993, following the passing of the DIT Act of 1992, its origins lie in the growth of technical education for trades at the end of the 19th century. This practical base is both a strength and a weakness, with good feedback from employers about the quality of graduates, but low female participation compared to the universities.

In the Academic year 2015-16, the numbers of first year Level 8 students studying engineering was 173, with 20 females, or 11.5%. The numbers of level 7 engineering students (general entry) was 66, with 7 females, or 10.6%. This has been relatively constant over the past decade.

2.3 Engineers Ireland

Engineers Ireland is the professional body for Irish engineers, both accrediting third level courses for membership, and representing engineers nationally and internationally. Its origins lie in the founding of the Civil Engineers Society of Ireland in 1835. This received a Royal Charter in 1877, which was amended by the Irish parliament, Dáil Éireann, in 1969 to set up The Institution of Engineers of Ireland – Cumann na nInnealtóirí, as the body to represent all engineering disciplines.

Engineers Ireland do a lot of work to promote engineering amongst the populace generally and students particularly. They run the STEPS programme for second level students with the following aims [13]:

1. Encouraging a positive attitude towards science, technology, engineering and mathematics
2. Introducing to students the relevance of science, engineering, technology and mathematics to industry and everyday life
3. Raising a positive awareness and understanding of engineering as a career choice
4. Promoting a greater understanding of the role and contribution of engineering in society

5. Highlighting the advantages, diversity, opportunities and excellent rewards offered by a career in engineering

STEPS run an engineering week for Transition Year (TY) students to encourage them to think of engineering when they choose their Leaving Certificate subjects. The week is gender balanced by design, although there are five times more applications from boys than girls. See Figure 1, below.

Fig. 1 TY Students in the turbine hall at Turlough Hill, May 2016

One opportunity missed by Engineers Ireland is their review of engineering programmes every five years. No questions are asked about gender balance; if this was seen as a key metric by the course providers, the universities and Institutes of Technology, they might make more effort to achieve a better balance.

3 CONCLUSION

Practice every day has made
Pangur perfect in his trade;
I get wisdom day and night
Turning darkness into light.

Turning darkness into light, as the monk claims to do in the last verse of his poem is a non-trivial problem. So is overturning centuries of engineering as the last bastion of the male club. Even those committed to equality fall short, as less than 10% of Engineers Ireland's members are female, and only 3.3% are fellows [7].

In March 1977, Rosabeth Kanter of Harvard [14] published a paper, *Some Effects on Proportions on Group Life: Skewed Sex Ratios and Responses to Token Women* in the American Journal of Sociology. In it, she identified 35% as the key proportion of women needed in the workplace for gender normality to occur. Below this figure, the workplace is male dominated and is either consciously, or unconsciously, hostile to women. Given that efforts to increase the number of female engineers have struggled to move much beyond the 20% mark, and even less in core areas such as Mechanical, it seems logical that quotas should be used in both universities and in public sector employment. As the current level of female engineering students seems to be stuck at around 20%, a starter figure of 25% by 2020, seems reasonable. This could then increase in ten year intervals by 5%, a feat that should not prove too difficult to achieve. An instant quota of 35% would be self-defeating. A level of 35%

would create not just a better gender environment, but also the role models and the increased awareness in the wider community of the richness and diversity of 21st Century Engineering.

A second alternative is to re-engineer engineering. If the product doesn't fit the person, change the product, not the person. Health sciences are extremely popular with female school leavers, with areas such as Medicine, Pharmacy, Veterinary, and Physiotherapy having over 80% female students. These are challenging areas, requiring very high points, disproving any notions that female students avoid 'difficult' areas. Then why not create courses such as Medical Engineering, with 50:50 content from medicine and engineering? Biomedical engineering is popular, but is usually seen as an option for traditional engineering students. Other possibilities are engineering courses with business, management, etc. Over time, such courses could erode the negativity surrounding engineering amongst women.

The alternative is to pursue the same initiatives as before, gradually increasing the number of female engineers over the next century. But the world needs female engineers now.

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