Will They, Won't They: An exploratory study of female final year civil engineering undergraduates and their persistence in civil engineering careers and the factors that motivate this decision.

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Abstract

Women in engineering have long been a minority. Reported statistics of enrolment in engineering in 2015 was 7.895% for general building and civil engineering. This study reported a much higher statistic of 18%. This elevated statistics may be due to the small population of civil engineers graduating this year, 100 to be exact. Lecturers report that while the overall numbers have fallen, the number of girls has remained static although the percentages may have increased.

A qualitative study was carried out over six learning institutions by conducting interviews with 6 final year female civil engineering students and got an additional perspective from two female lecturers.

Thematic analysis was conducted through its three stage to extract three overarching themes that explained the low numbers of girls in civil engineering as the nurturing nature of females and civil engineering doesn't fit this value, the personality type that is attracted to engineering, the self confessed anomalies and the social and cultural influences that believes women are not suited to civil engineering.

Declaration

Submission of Thesis and Dissertation

National College of Ireland

Research Student's Declaration Form

(*Thesis/Author Declaration Form*)

Name: Dorothy Kavanagh

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Transition Year	TY
Science, Technology, Engineering and Mathematics	STEM

1. Introduction

In 1995 Bronzini, Mason Jr., Tarris and Zaki produced market research findings about choosing a civil engineering career, these included poor statistics on female involvement as well as a weak campaign for recruiting women and ethnic minorities. Fast forward twenty years and the situation hasn't changed much. In fact Irish female enrolment of civil engineers are on average 6.6% less than Bronzini *et al*. reported in 1995.

The vast majority of studies done on progression from degree to career in female engineering students have been based in the US (Lichtenstein, *et al*., 2009; Amelink & Creamer, 2010; Bronzini, *et al*., 1995; Woodcock, *et al*., 2012; Amelink & Meszaros, 2011). Understanding the Irish population of female final year undergraduate students is crucial particularly in 2015. With the economy on the rise, more civil engineers will be required to start projects that were put to one side or stopped as the recession hit. If diversity is the solution to innovative and creative problems then understanding what the industry needs to do to encourage females into it is vital for our economy.

2. Literature Review

2.1 Introduction

The literature review chapter will cover the need for gender diversity in engineering, undergraduate engineering degrees, these degrees as means to another career or path, female role models within engineering, feelings of tokenism, sexism and stereotype threat. There is dearth of research on civil engineering so literature included will be on engineering in general as well as using internet sources to create the Irish situation.

2.2 Diversity

Gross (2012) describes engineers as historically first generation college males; their fathers were blue collared foreman, Concannon and Barrow (2010) concur with describing the profession as male dominated. Engineering is and historically has been a social role that is percieved as a male career (Taylor, 2010). The sector desperately needs an increase in gender diversity.

2.2.1 Diversity definition

The definition of diversity has changed in the last twenty years from pure demographics mentioned in Esty, Griffin and Schon-Hirsch's (1995) definition (cited in Green, Lopez, Wysocki and Kepner, 2012) to a more fluid definition by Van Knippenberg, De Dreu and Homan (2004) (cited in Guillaume, Dawson, Otaye-Ebede, Woods, and West, 2015) which doesn't list any specific differences as mentioned in Esty *et al.*'s (see **Appendix 1**). McMahon (2010) states specifically that diversity has gone past demographics to include variables that are non-linear, i.e. cannot be conceptualised on one scale, such as knowledge, skills, abilities and experiences. Simpler explanations from a GradIreland (2009) article are what is done about differences between people and how these differences are recognised. Within the engineering sector, there is a chronic lack of diversity in gender with one study showing a low of 7% in the engineering workforce in the UK (Ayre, Mills and Gill, 2011).

2.2.2 A business case for diversity- why is diversity important?

While many studies and articles make a business case for diversity how it positively impacts on organisation performance and their bottom line, there are those that oppose this. McMahon (2010) and Armstrong, Flood, Guthrie, Liu, MacCurtain and Mkamwa

(2010) found little direct effects of diversity on performance. Chrobot-Mason and Aramovich (2013) concur by saying that studies they had reviewed showed support for business strategy, organisational design and culture and human resource management practices all playing a significant role in effectively managing diversity to gain maximum positive impact. Having diversity is not enough, it has to be managed to create a supportive and inclusive environment where employees feel secure and included to offer ideas, solutions and suggestions (Chrobot-Mason and Aramovich, 2013).

Once the environment is effectively managed creativity, problem solving and innovation increase, decision making improves, potential customer base expands and accumulates in increased competitiveness for the organisation (Guillaume et al., 2015; Nakagawa and Schreiber, 2014; Patrick and Kumar, 2012 and Mahon, 2010). Otherwise the double edged sword leads to an increase in conflict, harassment, discrimination and turnover and a decrease in employee morale and job performance (Guillaume *et al*., 2015; Chrobot-Mason and Aramovich, 2013).

McMahon (2010) proposes a stronger business case for diversity in service industries due to the individual customer based interactions, customising these interactions will create a more positive image for the company. While engineers can work in companies with fewer interactions with customers, those working in consultancies need to be able to adapt to different customers and especially coming out of a recession engineering firms need to create a good employer brand for themselves and managing diversity may be the way to create that competitive advantage to put themselves ahead of their competitors.

2.2.3 Gender diversity in senior management in Ireland

In Ireland, 6% of companies have a female board member and the most recent recession showed homogeneity at senior management can lead to narrow thinking and a lack of challenging proposed decisions (McCann, 2015). As the engineering sector was critically affected by the recession, they would want to avoid repeating any mistakes that compounded the recession's impact.

Giving diversity as an answer to creativity and innovation problems is all well and good but how does an organisation increase diversity through recruitment if the quality

applications that come in are primarily male? If there are limited female engineers out there, how is this improved?

2.2.4 Gender diversity in engineering compared to the general workforce

Within the literature varying levels of general and engineering female participation in the workforce is reported which are compiled in **Table 2.1**.

The UK and the USA have the greatest breadth of studies but studies don't always agree such as the case of the USA where three studies report statistics of 8.5, 20 and 10.2% for 2002, 2004 and 2005 respectively (Rosenberg-Kima *et al*., 2010; Bucak and Kadirgan, 2011; Smith and Dengiz, 2010) . While 2002 and 2005 make sense, 2004 is an outlier. More importantly is the difference between general female workforce participation statistics and those in engineering; 56.8% vs 8.5% in the USA in 2002 (Rosenberg-Kima *et al*., 2010), 46.4% vs 6.3% in the UK in 2011 (Powell, Dainty and Bagilhole, 2012) and a general workforce participation rate of 56.1% in 2014 (McCann, 2015) compared with less than 15% of the engineering workforce being female in 2010 in Ireland (Dobson, 2012).

The most important point to take note of is the little or no growth of female participation in the workforce in comparison to the growth of female participation in the general workforce as shown in Bangladesh and Ireland (McCann, 2015; Saidfuddin, Dyke and Rasouli, 2013; Dobson, 2012 and Cross, 2010).

Table 2.1 Percentages of females in the general workforce and engineering workforce by country

Year	Percentage of total females in workforce	Percentage of females in engineering workforce	Country	Source
2009		14%	Australia	Andrews and Clark (2012)
2011		11%	Australia	Ayre, Mills and Gill (2011)
2012		<10%	Australia	Dobson (2012)
2010		<15%	Austria	Dobson (2012)
1996	16%		Bangladesh	Saidfuddin, Dyke and Rasouli (2013)
2003	26%		Bangladesh	Saidfuddin, Dyke and Rasouli (2013)
2010		>25%	Bulgaria	Dobson (2012)
2012		10.5%	Canada	Dobson (2012)
2010		>25%	Croatia	Dobson (2012)
2010		>25%	Cyprus	Dobson (2012)
2006		8% (construction)	EU	Powell, Hassan, Dainty and Carter (2009)
2010		<15%	Finland	Dobson (2012)
1971	28%		Ireland	Cross (2010)
2007	59%		Ireland	Cross (2010)
2010		<15%	Ireland	Dobson (2012)
2014	56.1%		Ireland	McCann (2015)
2010		>25%	Lativa	Dobson (2012)

2010		>25%	Lituania	Dobson (2012)
2010		>25%	Poland	Dobson (2012)
2010		<15%	Switzerland	Dobson (2012)
1989		24%	Turkey	Smith and Dengiz (2010)
2006		10%	UK	Powell, Hassan, Dainty and Carter (2009)
2010		8.5%	UK	Dobson (2012)
2010		9%	UK	Andrews and Clark (2012)
2011		7%	UK	Ayre, Mills and Gill (2011)
2011	46.4%	6.3%	UK	Powell, Dainty and Bagilhole (2012)
1982		< 3.6%	USA	Concannon and Barrow (2010)
1986		4.057%	USA	Concannon and Barrow (2010)
2002	56.8%	8.5%	USA	Rosenberg-Kima, Plant, Doerr and Baylor (2010)
2004		20%	USA	Bucak and Kadirgan (2011)
2005		10.2%	USA	Smith and Dengiz (2010)
2011		11%	USA	Ayre, Mills and Gill (2011)
2011		11%	USA	Andrews and Clark (2012)
2012		11%	USA	Dobson (2012)
2013		10% (full time employed)	USA	Buse and Bilimora (2013)

2.3 Undergraduate engineering degrees

The answer may be found by looking at a few steps before recruitment, i.e. in the university and college engineering degrees. By decreasing attrition from these degrees and encouraging females to go on to engineering careers rather than to other sectors such as the financial sector. To achieve these goals a greater understanding of what factors encourage girls to visualise their career in engineering and aspire to join the sector.

Chemical engineering is the most popular branch of engineering according to Dr. Alana Collis of the Institute of Chemical Engineers (The Engineers Journal, 2013), which is consistent with findings from Turkey that girls not only preferred chemical engineering but perceived that it was a "more appropriate" career for women (Bucak and Kadirgan, 2011). On the other end of the scale, the perceived male appropriate career branch is civil engineering (Bucak and Kadirgan, 2011).

In most Irish learning institutions, first year students start off in general engineering and they can experience the various branches before choosing a particular branch. Meyer and Marx (2014) were concerned with dropouts and they state that any dropouts are a huge loss to the qualified working population as well as a financial drain to the economy especially in Ireland where the vast majority of undergraduate degrees are paid for by the state.

Understanding what institutions can do to encourage female students to remain in their engineering degree is vitially important as girls have to make it through their degree before being able to be employed as an engineer. Amelink and Meszaros (2011) cite student engagement (being actively engaged with college faculty, staff, other students and their subject) as being a main factor as well as motivation. Lichtenstein *et al*. (2009) agree on this factor being involved in progressing into a career.

Bronzini *et al*. (1995) reported declining numbers of numbers of civil engineering graduates in the USA and their opinion was that in the profession in general were doing a poor job of recruiting women and ethnic minorities. They stated that 16.5% of undergrad engineers in the US were female, fast forward twenty years and that has

increased to a mere 18% (The Engineers Journal, 2013). This proves the problem of underrepresentation of women, especially in the US is deep set.

Currently 20% of Ireland's engineering undergrads are female compared to Britain's 15-16% (The Engineers Journal, 2013; Powell et al. 2012).

Table 2.2: Percentage of females enrolled in or received engineering undergraduate degrees by country.

Country	Year	Percentage of females	Source
Australia	2009	15.7%	Dobson (2012)
Austria	2001	11%	Bucak and Kadirgan (2011)
Bangladesh	2009	20%	Saifuddin, Dyke and Rasouli (2013)
China	2012	40%	DIT (2012)
Germany	2001	28%	Bucak and Kadirgan (2011)
Germany	2005	20%	Bucak and Kadirgan (2011)
Ireland	2012	10%	DIT (2012)
Ireland	2013	10%	The Engineers Journal (2013)
Ireland	2013	13.4%	HRM Recruit and Engineers Ireland (2013)
Ireland	2013	7.248% (building and civil engineering)	Higher Education Authority (2013a)
Ireland	2014	7.246% (building and civil engineering)	Higher Education Authority (2014a)
Ireland	2015	7.895% (building and civil engineering)	Higher Education Authority (2015a)
UK	2007 - 2008	16.4% (engineering and technology)	Powell, Dainty and Bagilhole (2011)
UK	1973	3% (engineering and technology)	Powell, Dainty and Bagilhole (2011)
UK	1984	8% (engineering and technology)	Powell, Dainty and Bagilhole (2011)
UK	1994	14% (engineering and technology)	Powell, Dainty and Bagilhole (2011)
UK	2010	15% (engineering and technology)	Powell, Dainty and Bagilhole (2012)
USA	1999 - 2002	18% (in a large state university)	McLoughlin (2005)

USA	1954	0.4%	Laefer (2009)
USA	1976	3.797%	Concannon and Barrow (2010)
USA	1983	13.3% 46.4% biology 28.5% physics	Sonnert, Fox and Adkins (2007)
USA	1995	16.5%	Bronzini, Mason Jr, Tarris and Zaki, (1995)
USA	1999	20%	Laefer (2009)
USA	2000	15.9% (civil engineering)	Leonard and Nicholls (2013)
USA	2002	20.9% 61.0% biology 42.7% physics	Sonnert, Fox and Adkins (2007)
USA	2004	20% 21% physics	Schreuders, Mannon and Rutherford (2009)
USA	2005	17%	Laefer (2009)
USA	2005	17.2%	Smith and Dengiz (2010)
USA	2005	22%	Smith and Dengiz (2010)
USA	2005	20%	Amelink and Creamer (2010)
USA	2007	~20%	Concannon and Barrow (2010)
USA	2008	20%	Rosenberg-Kima, Plant, Doerr and Baylor (2010)
USA	2009	20% (civil engineering)	Leonard and Nicholls (2013)

USA	2013	18%	The Engineers Journal (2013)

Table 2.3: Average female enrolment in or received general undergraduate degrees by country

Country	Year	Average female participation	Source
Australia	2009	55.4% (of 1.13 million)	Dobson (2012)
Bangladesh	2009	22 – 24%	Saifuddin, Dyke and Rasouli (2013)
Ireland	2013	52.773%	Higher Education Authority (2013b)
Ireland	2014	52.592%	Higher Education Authority (2014b)
Ireland	2015	52.519%	Higher Education Authority (2015b)
UK	2007/2008	57.1%	Powell, Dainty and Bagilhole (2011)
UK	2011	57%	Powell, Dainty and Bagilhole (2012)
USA	2008	22%	Smith and Hung (2008)

2.4 An Engineering degree as means to another path

Boselie (2010) mentions the problem of recruiting from a specific technical background as changes in markets and organisation can happen at such a fast pace that other professional backgrounds may be more useful over time.

2.4.1 Transferable skills gained

Transferable skills can be described as skills that are acquired and developed in one area such as education and can be used effectively in another, they are often not job or discipline specific (Chadha and Nicholls, 2006). Engineering's transferable skills include; analytical and logical thinking, attention to detail, creativity, data analysis, laboratory skills, numeracy, statistics and computer skills, organisation skills, problem solving, project and time management, research skills, team work and communication (Brightside Online Mentoring, 2015; GradIreland, 2015 and TCD, 2014).

2.4.2 Alternative careers

With the wealth of non-discipline specific skills attained from an engineering course, it is no wonder that engineers are in demand from sectors such as; business and management, finance, fire prevention and safety, IT, law, management consulting, operations research, teaching and lecturing, technical sales and writing (GradIreland, 2015; HRM Recruit and Engineers Ireland, 2013). 40% of engineering graduates work in non-engineering careers with general management being most popular at 27.2% of the 40%, operations and IT claimed 15.2% and 10.6% of graduates respectively (HRM Recruit and Engineers Ireland, 2013).

2.4.3 A leaky pipeline

Fouad and Singh (2011) conducted a study in the US with 5,500 women, they found 10% left college or university with an engineering degree but didn't continue on to develop a career and 29% who entered the career left citing workplace climate and a lack of flexibility, support and respect. Amelink and Meszaros (2011) don't give specific statistics but say that longitudinal data shows that females are less likely than males to continued on to an

engineering career. Powell *et al*. (2012) report that 51.5% of women from institutions in the UK go on to an engineering career in comparison to 70% of men. This is slightly contradicted in the same article, reporting only 6.3% of engineering professionals were women. While in America, Lichtenstein *et al*. (2009) found that 58% of men and women were either unsure or definitely not intending to continue in the engineering profession. Dr. Collis was reported saying that women need encouragement, support and to feel confident in themselves and their career to not only stay in engineering but to enter the profession in the first place (The Engineers Journal, 2013). Concannon and Barrow (2010) echoed this confidence in career argument but generallising it for men and women saying that to complete a degree program, a student needed to believe that their career prospects were realistic and attainable.

2.4.1 Disparity

If in Ireland, 40% of all graduates (males and females) are leaving for non-engineering careers then there should be a 88:12 gender split in engineering, not the 90:10 split that is reported (The Engineers Journal, 2013). In the Engineers Ireland report, they state that men outnumber women by nearly nine to one and give specific figures of 86.6% men and 13.4% women (HRM Recruit and Engineers Ireland, 2013). One reason for this disparity between reports by Engineers Ireland and others may have been because people surveyed were not all working in Ireland, 13.4% were working overseas (HRM Recruit and Engineers Ireland, 2013). What would have been interesting to see is the split between those working in Ireland and those working abroad; are more women proportionally working abroad with Irish qualifications than men? It would have given a greater insight to what the Irish working population of engineers stands at.

2.5 Female engineers as role models

As part of National Engineering Week 2012 (now called Engineers Week (Engineers Week, 2015a)) DIT hosted an event purely for secondary school girls to inspire them to pick careers in Science, Technology, Engineering and

Maths (STEM) (DIT, 2012). Deirdre Staunton (College of Engineering and the Built Environment at DIT (DIT, 2008; DIT, 2012)) was quoted in saying:

> "girls have to perceive they can be engineers before they can be engineers" and "nothing conveys that message as effectively as having mentors and role model" (DIT, 2012).

However looking at the prospective student webpages of various level 8 courses in institutions across Ireland this message doesn't come across when girls go to research various courses before submitting their CAO choices.

2.5.1 Student examples on institution websites

Male students were used exclusively as examples in Cork IT and DIT (CIT, 2012a; CIT, 2012b; DIT, 2008). A male student talked about the civil engineering course in UL's video where 1 female lecturer and two females students were shown in background shots (UL, No Date) however looking at the still video on the introduction to the course page only showed the male student and a male department staff member (UL, 2014). UCC had the best proportion of male-female student examples on the graduates page where 4 females' stories where alongside 4 male graduates (UCC, 2015a). UCD listed one graduate story which was female on their website (UCD, 2014). UCC and UCD both best represented girls but UCC showed both sides of gender stories while UCD may be interpreted as "the token girl" by some more cynical viewers.

2.5.2 Staff member breakdown

While student stories might have a more equal gender distribution, looking at staff members of the departments wasn't. In UCC's Civil Engineering department there was only one female lecturer with 17 other male lecturers (5.56%) (UCC, 2015b), half the average female statistic (HRM Recruit and Engineers Ireland, 2013). NUI Galway seemed to have the best representation with 6 women out of 37 staff (16%), however one women was an administrative staff member (NUI Galway, No Date) which artificially inflates the percentage from the average 10% female population (HRM

Recruit and Engineers Ireland, 2013). UCD list three females out of 20 staff members (15%) for the Civil, Structural and Environmental Engineering department (UCD, No Date). While universities and colleges can deliberately manipulate gender balance of past graduate or current student that they show on their websites for potential or incoming students to look to, there is little they can do regarding the gender balance among staff members, especially lecturers.

These staff statistics are from Civil Engineering departments and may not all be lecturers. Trinity College provided statistics on their academic staff on the Centre for Women in Science and Engineering Research website (WiSER, 2014). They report that 39% of all Trinity academic staff is female but only 22% of the Faculty of Engineering, Maths and Science academic staff are women (WiSER, 2014). While eight out of the 25 schools have a female head of school, none of the schools in Engineering, Maths and Science have a female head (WiSER, 2014).

2.5.3 Professional bodies in Engineering

Engineers Ireland is the representational body for all engineering disciplines in Ireland (Engineers Ireland, No Date) while the Institution of Strutural Engineers (IStructE) is an international body representing the discipline of structural engineering (Institution of Structural Engineers, 2015a). The Republic of Ireland Branch of IStructE's 2015 Committee has 21 members filing various roles of which six are women (28.571%) (Institution of Structural Engineers, 2015b). Although the Engineers Ireland's Council is larger at 44 members, the proportion of women is smaller at 10 women (22.727%) (Engineers Ireland, 2014). At the Executive Board of Engineers Ireland, where members are elected from the Council, the proportion of women is smaller again at 20.000% (Engineers Ireland, 2014).

Amelink and Creamer (2010) explicitly stated that having effective female roles in the department was significantly related to pursuing a career in engineering. While undergraduate girls have plenty of females CEOs to look up to such as Anne O'Leary, CEO of Vodafone Ireland (Kennedy, 2013) and

Anna Malmhake, CEO of Irish Distillers Pernod Ricard (Irish Distillers, 2012), they have limited if not no examples of females reaching the top of the organisation in their own learning environment.

2.5.3 Are role models equally distribution between staff and students?

While UCC showed the male and female side of graduate or student experiences, they had the worst male female breakdown of staff members of those seen. NUI Galway had the best gender ratio but there were no graduate or student stories that would have been seen by girls researching what course they wanted to do. Universities need to be more concise from a marketing point of view when designing webpages for potential students, this author would suggest UCC's method of both sides of the story rather than risk the "token girl" aspect.

2.6 Feelings of tokenism

Amelink and Meszaros (2011) found that girls were wary of attending special events (such as Women into STEM for the Irish Engineers Week 2015 (Engineers Week, 2015b)) for fear of being seen as different or set apart from their males peers. However Amelink and Meszaros commented that the feeling of tokenism in departments can be diminished by females students integrating into the department, for examply by attending engineering-related events.

2.7 Sexist and gender bias behaviour

Girls reported in Amelink and Meszaros (2011)'s study the need to develop a "tough skin" to combat the sexist and gender biased behaviour that is the norm in many departments. Jones *et al*. (2013) supported this reporting that the culture of departments was one of the main reasons for female engineers leaving before completing their degree alongside negative stereotypes about the engineering and mathematical ability of women. While Powell *et al*. (2012) found that there is a gender stereotype and a masculine culture, they reported that the women in their study found excitement and pride in being female in a male-dominated environment. They even went as far to set

themselves apart from other women saying that engineering is more suited to males (Powell et al., 2012).

3. Research Questions

700 words

Objectives have been clearly specified and are creative and appropriate. Objectives have been fully achieved or surpassed. The research is novel or stretching in terms of

1. Do female final year civil engineering students intend to continue in an engineering career and what factors influence this decision?

2. What motivates females to choose a civil engineering course?

3. Do institutions with incentives and support programs for females encourage females to continue in the engineering field? Do females feel they need these support programs?

4. What role does female staff play, if any, in females' perspectives and enjoyment of civil engineering?

5. What are the females perspectives on what can improve numbers in civil engineering?

4. Methodology

4.1 Introduction

The Methodology chapter will detail the steps taken in this study and explain the reasons behind the choice of research methods implemented and how they are routed in the literature. The study is concerned with understanding the low numbers of girls in engineering; in particular civil engineering; what motivated the current girls to choose civil engineering and what can be done to improve the numbers of girls in engineering.

The many layers and facets of the factors involved with research design are consciously presented by Saunders' Research Onion (See **Figure 4.1**) (Thornhill, Saunders and Lewis, 2008). The methodology chapter will follow these layers [philosophy, approach to theory development, methodological choice, strategies (or research instrument), time horizon, techniques and procedures (data collection and analysis)] in order as well as defining the research sample, detailing the strengths and limitations of the chosen methodological choice and any ethical considerations.

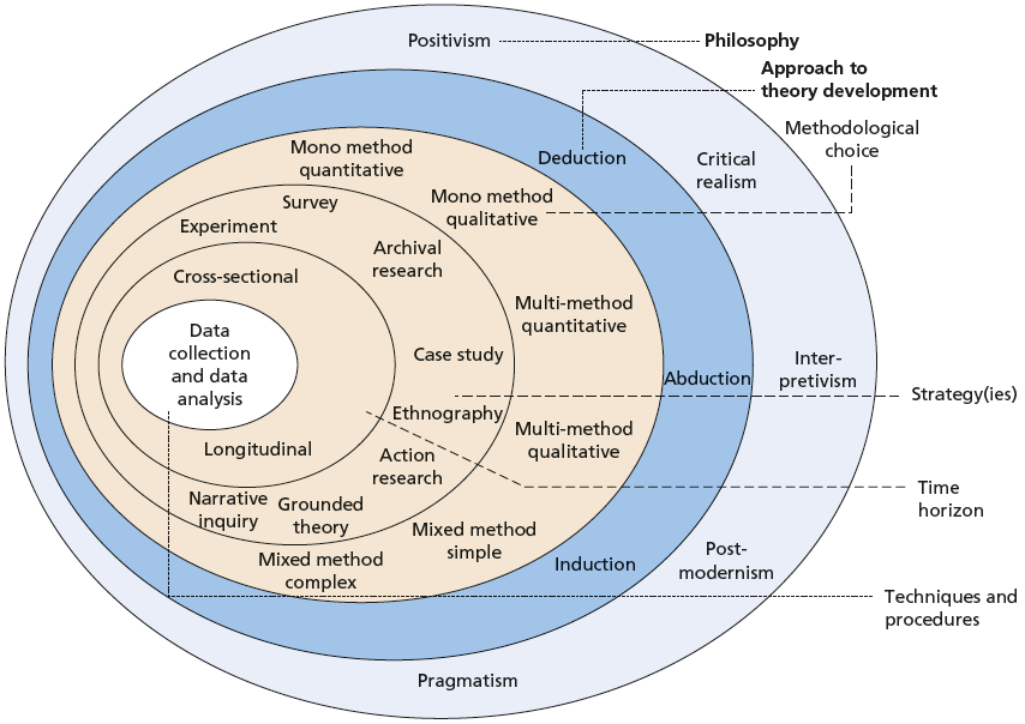

Figure 4.1: Saunders' Research Onion (Source: Saunders, Lewis and Thornhill, 2015).

4.2 Research philosophy and approach

The author's philosophy is positivism which believes research of any discipline can be conducted using scientific methods of using observable ad objective facts (Saunders, Lewis and Thornhill, 2015; Saunders and Tosey, 2012; Snape and Spencer, 2003). From the author's philosophy the original research design was quantitative with questionnaires as the research instrument.

However considering the small numbers enrolling in civil engineering undergraduate courses due to the recession (personal correspondence with learning institutions) and the small proportion of girls in these undergraduate courses (see **Table 2.2**: Percentage of females enrolled in or received engineering undergraduate degrees) along with the time of year (after final year students would have completed exams and left on summer holidays and/or to jobs) it was decided that a qualitative approach would garner more probing information even with a small sample group. Qualitative

data would also give further insight in the students' discourse (Powell, Dainty and Bagilhole, 2012).

While following Saunders' Research Onion from philosophy to approach, the subsequent approach of the positivism philosophy would be a deductive approach. However considering the qualitative nature of the study, a deductive approach would be misaligned as it would develop a hypothesis first and then prove the null hypothesis false from the data collected (Saunders *et al*., 2009). Therefore a inductive approach was used, looking at the data and creating concepts and themes from it.

4.3 The research focus

The research focus of the study was to investigate and explore the factors that encouraged females to enter and complete a civil engineering undergraduate degree. Also investigated was being a minority in a male dominated industry.

4.4 Research Sample

The research population were final year female students from Level 8 civil engineering courses from six learning institutions across the Republic of Ireland. One learning institution reported as having no girls in their final year. The remaining five institutions' numbers are detailed in **Table 4.1**.

Table 4.1: Research population

Institution	**Number of females**	**Numbers of males**	**Number of females interviewed**
Institution of Technology #1	3	22	2
University #1	4	15	1
University #2	4	18	1
University #3	3	19	2

University #4	4	8	1[1]
Total:	**18**	**82**	**7**
Percentage of total	18.000%	82.000%	38.889%[2]

4.5 Research instrument

In-depth and unstructured interviews were chosen as the qualitative method for this study. Legard, Keegan and Ward (2003) describe these types of interviews as a form of conversation.

4.5.1 Student interview questions

1. Tell me a bit about yourself.

    Including age, background, any family or friend connection to engineering or construction.

2. How have you found studying civil engineering?

3. What factors influenced your decision to enter the course?

    Was it as you expected?

4. How do you feel about the ratio of women to men in engineering?

5. Are there any incentives or support programs encouraging girls to engage with engineering in the college?

    What types of programs are there?

    Did you avail of any of them?

    What is your opinion on them?

    Do the lecturers lend any support?

6. What were your favourite and least favourite parts of the course?

[1] The recorded. Interview was initially transcribed and found to be far too conversational and wandering and so was excluded from analysis.
[2] Percentage of females interviewed out of total females.

7. Have you completed any work placements within or outside college?

Any Transition Year work experience?

8. What are your intentions regarding a future career? Do you plan to stay within engineering?

When did you make a decision about this?

Who and/or what influenced your decision?

9. Where do you see yourself in three or five years' time?

10. Is there anything else you would like to mention or talk about?

4.5.2 Lecturer interview questions

Tell me a bit about yourself and your background.

2. How have you found working in civil engineering?

3. Why do you think there is such an imbalance in the number of women to men in engineering?

4. Are there any incentives or support programs encouraging girls to engage with engineering in the college?

What types of programs are there?

Do students avail of any of them?

Do you think these programmes are effective?

What type of support do the lecturers lend towards encouraging students and girls in particular towards careers in engineering?

5. What are the general intentions of past and present girls regarding a future career? Do they plan to stay within engineering?

When do they generally make a decision about this?

Who and/or what influenced these decisions?

6. Is there anything else you would like to mention or talk about?

4.6 Time frame

The time frame for interviewing the students was between June and August 2015. Within the time frame of a twelve month masters program only a cross-sectional study was possible. Ideally the study design would follow the longitudinal design of Lichestein *et al*. (2009) to follow the changing patterns of career decisions and thought process behind these decisions throughout the four year program, the masters program (one year full time or two years part time) and to the first career job post third level education. However given the time frame and the level of masters program, this would be impossible.

4.7 Strengths and limitations of methodological choice

4.7.1 Limitations

Sivo, Saunders, Chang and Jiang (2006) discuss the advantages of quantitative research in particular questionnaires; these include the low cost and ease of reaching varied geographical demographics by using web based questionnaires. People may be more open and honest about sensitive or personal information in questionnaires than in face-to-face situations (Sivo *et al*., 2006). Given the wide spread of geographical locations for each of the learning institutions, time and financial costs would have been less with online questionnaires.

Qualitative data is interruptive and subjective which isn't consistent with the research philosophy of the author. Holden and Lynch (2004) warn of the danger of mismatching research philosophy to research design as it may give rise to false results.

4.7.2 Strengths

While Sivo et al. (2006) believe in honesty in questionnaires, Fowler Jr. (2009) believes that if the interviewer is able to build a rapport with the participants in person, they can safely probe for more adequate information without making the participant feel under pressure.

4.8 Data collection

4.8.1 Making contact with schools and departments

Civil engineering courses were searched for on the Engineers Ireland website to select learning institutions and six fit the criteria of being a Level 8 course (STEPS, 2013). Each learning institution were searched on Google for the head of department/school name along with contact information (email address and phone number). An email was sent to each head of department or school explaining who the author was, what the study was about and what type of students were included in the sample group (see **Appendix 1**).

One institution replied by email immediately saying that no girls were enrolled in their final year class.

Each email was followed up a day later with a phone call. Some contact information was incorrect on institutions' websites such as a head of department having retired a few months earlier and a new contact name and number was obtained. Some phone numbers rang out several times and in these cases, the secretary or office of the department or school was called.

One head of department couldn't be contacted over a week or two and another contact was obtained through a family connection. This contact was emailed and followed up with a phone call as before.

Once verbal contact was made with the department or school, the author was introduced, explained that an email had been sent previously and described the study purpose. Some contacts gave their detailed insights into the problem and these were later emailed to ask for an in depth interview to discuss their professional insights to the civil engineering education system and industry. They were then asked to make contact with their students or forward on the original email.

One head of department required evidence of ethical clearance before contacting students. A form with Ethical Risks and Confidentiality and Data

Protection along with the study's supervisor's contact details for assurance was sent and approved by the head of department (See Appendix 2).

4.8.2 Making contact with the students

Some students emailed the author directly; others were carbon copied on emails sent from the head of department/school or had replied to the author's forwarded email.

Interviews were arranged through emailing the students directly and students were asked if they were comfortable with being recorded before explaining that they would be asked to sign a consent form.

4.8.3 Interviews

Interviews were recorded on two HTC phones using the phone's recording software. Two phones were used to record in case one phone malfunctioned.

The study and its background was explained to each participant before explaining the consent form (See **Appendix 4**) including the anonymity of the participant and the ability of the participant to withdraw from the study before the participant signed the form.

4.8.4 Interview transcription

Interview recordings were transcribed with a downloaded program Transcribe (available from Google Chrome App Store) which can slow recordings down by half the normal speed for ease of transcription. It is advised to transcribe with all details of the conversation, known as Transcript Notation, including length of gaps, emphasis or stress on words and pace of speech (Rapley, 2001). This is because often for sensitive or probing questions, participants offer information or further clarification if the interviewer remains silent (Rapley, 2001). For ease of reading and speed of transcription, transcript notation was not used. No particular sensitive information such as the example given by Rapley (2001) of drug use was examined in the study.

4.8.4.1 Anonymity

Given the extremely small sample population and smaller sample group (see **Table 4.1**) anonymity was very important as maintaining confidentiality of any information gathered through interviews is critical (Babbie, 2014). Any deciphering details about the participant or learning institute were removed or blocked out. Interview code names were given by randomly picking names alphabetically with student interview number (Interview 1 = A, Interview 2 = B, Interview 3 = C etc).

Table 4.3: Student code names

Interview number	Date	Code Name
1.	3rd of June 2015	Amy
2.	3rd of June 2015	Betty
3.	8th of June 2015	Caroline
4.	11th of June 2015	Debbie
5.	6th of July 2015	Elaine
6.	6th of July 2015	Fiona

Interviews with lecturers were given code names continuing in the same order as the students.

Table 4.4: Lecturer code names

Interview number	Date	Code name
1.	8th of June 2015	Dr. Harriet
2.	10th of June 2015	Mrs. Ivy

4.9 Data analysis

4.9.1 Thematic analysis

Thematic analysis was selected to analysis the raw data. Braun and Clarke (2006) describe this method as one for discovering, analysing and reporting

patterns within the data. Harding (2013) explains the aim of thematic analysis is to examine differences and relationships across various interviews rather than individual cases.

4.9.2 Thematic Analysis: Stage One

Stage one of thematic analysis commenced by reading transcripts, noting interesting sections and identifying themes that jumped out at the author. At this stage it was important for the author to remember to have an open mind and strive to emulate the inductive approach that countered the author's basic deductive approach.

Stage one was concerned with recounting the participants' experiences and thoughts throughout their undergraduate degree as well as taking on face value the thoughts and ideas of how to increase participation rates of females in these degrees.

Upon reading, 16 preliminary codes were identified and colour coded for ease of analysis (see Appendix 7). On rereading these codes were further broken down to merge comments from participants for the crucial cross-analysis mentioned by Harding (2013)

4.9.3 Thematic Analysis: Stage Two

To force the author to keep their inductive approach rather than their natural deductive approach, King and Horrick's (2010) advice not to apply theoretical concepts just yet was observed and followed. This was crucial to allow the data to be thoroughly combed to find interpretative levels that could be guided towards answering research questions. The transcripts were cross-analysed repeatedly until strong meanings became apparent thus adding another building block to the foundation of the research.

4.9.4 Thematic Analysis: Stage Three

From the interpretative level themes, three over-arching themes were extracted that answer the overall question of why there are so few women in engineering. These over-arching themes were consolidated from themes at each analytical stage.

4.10 Ethical considerations

4.10.1 Anonymity

As discussed in section **4.8.4.1**, with a small sample group from a small number of institutions, the identity of the participants could be easily recognised by those in the industry. While every attempt was made to disguise their identities by using code names and blacking up any distinctive details, the participants were aware at the time of signing the consent form that those from their learning institutions (staff or student) reading the dissertation may be able to make an educated guess as to the six learning institutions and by the transcripts identity the participants.

4.10.2 Putting participants under pressure about future plans

Asking questions such as questions 8 and 9 in **Table 4.2** about career plans and where the participant would be in three to five years may make the participant uncomfortable and uneasy. They may not have thought about this, having just focused on getting through their four year undergraduate degree. Having to think about this and answer to a complete stranger may have put them under stress.

5. Findings

5.1 Introduction

The Findings chapter will commence with the backgrounds of the participants, then taking the reader through each of the stages of thematic analysis and resulting themes and ideas that emerge.

Finally a clarification of a misperception of the author and an interesting gender balance found in research papers will be looked at.

5.2 Background of participants

The background of the participants is important as the participants do not stand alone in their experiences or their environment.

5.2.1 Amy

Amy is 25, from an urban area, has a father who is a builder and a close family friend who is a structural engineer. She completed 4th year or Transition Year (TY) in secondary school and did a week's work placement in an engineering office. She originally applied for Architectural courses and started an Architectural Technology course in an Institute of Technology. After 18 months and studying a Structures module, talking to the lecturer who was an engineer and the head of the engineering department was influenced to drop the Architectural Technology course and transfer into Engineering Level 8 in an urban Institute of Technology.

5.2.2 Betty

Betty is 25 and has two cousins involved in construction. She completed TY and did two weeks work placement in a music venue. Her Leaving Cert. subjects were Biology, Home Economics and Music. She didn't do honours maths for the Leaving Certificate and started a level 7 ordinary degree and transferred into Engineering Level 8 in an urban Institute of Technology.

5.2.3 Caroline

Caroline is 32, is from a commuter town, attended a mixed school and took Technical Drawing for her Leaving Cert. She graduated from an Architecture

course in a rural Institute of Technology and worked as a technician until being let go during the recession. She completed a Level 6 cert in civil engineering in an urban Institute of Technology while working and completed a Level 8 civil engineering degree in a University.

5.2.4 Debbie

Debbie is 23, is from a rural area. She originally wanted to do Architecture and choose to do civil engineering as a backup in an urban Institute of Technology where she completed the Level 6 and 7 over three years. She transferred into a Level 8 civil engineering in a University.

5.2.5 Elaine

Elaine is 22, was born overseas and is from an urban area. She has an uncle who is an engineer. She went to a mixed school and her Leaving Cert. subjects were Applied Maths, Designing Communication Graphics and Physics. She applied to the CAO and completed a Level 8 civil engineering degree in a University.

5.2.6 Fiona

Fiona was born overseas and is from a semi-rural area. Both her parents studied engineering in college and her mum left to be an accountant while her dad owns an engineering company in a foreign country. She went to an all girls' school and did accountancy, physics and technology for her Leaving Cert. She attended University to complete a Level 8 civil engineering degree.

5.2.7 Dr. Harriet

Dr. Harriet completed a civil engineering degree before taking on a PhD in an overseas city and in her last year juggled her PhD with working back in her original University where she went on to lecture for three years before moving Universities where she has been for the last 12 years.

5.3.8 Mrs. Ivy

Mrs. Ivy gained her four year masters in civil engineering abroad , worked in various consultancies around the country for 18 years before becoming a

part time lecturer and then a full time lecturer in her Institute of Technology where she has been for the last four years.

5.3 Thematic Analysis: Stage One

16 preliminary codes were found which related to three basic and slightly overlapping themes of background, engineering and girls within engineering. Percentages are given here in line with the author's scientific philosophy but the limitations of such a small sample group of six students can be misleading if read independently from the methodology section.

5.3.1 Family connection to engineering

Amy and Fiona both had strong family connections to engineering with Betty having a weak link in her two cousins. Interestingly the girls' perceptions of their fellow male students were conflicting as one girl said that her friend wouldn't have any connections or reasons to get into engineering while another said that a couple males had family connections, always being the father.

5.3.2 Continuing on in engineering

Five out of the six of girls (83.333%) intended to continue on in engineering with one girl realising she never wanted to be an engineer at all.

> "I decided I didn't want to be an engineer at all. I didn't enjoy figuring stuff out and I didn't enjoy the problem solving. [What] I enjoy is the planning of a project. [I would want to be a] project manager for engineering companies as opposed to an engineer who does project management"

However while two girls decided to work and complete the Engineering Masters part time, one girl didn't want to progress up the corporate ladder claiming that as an engineer once a certain point engineering work gives way to management work. This was echoed by two other girls.

> "As you move up the ladder in a company the only place you can go is into management. [You] will move away from engineering into management. [You won't] really [be] doing the engineering stuff."

One girl didn't define whether she intended to attempt an engineering masters but indicated that moving to part time at some stage for potential children or moving out of engineering entirely were both options for her.

5.3.3 Girls within engineering

5.3.3.1 Banding together

83.333% of the girls interviewed claimed in one way or another that having another girl in the course with them was of some comfort

5.3.3.2 Need to be comfortable around males

83.333% of the girls expressed a need or a want to be around males to the extent that even though one girl had said it was comforting to have at least one girl in the course with her that;

> "I think if there were a lot more girls in the class I'd be a lot more panicked."

As well as a perception that girls coming from an all girls' school would be at a disadvantage for not having spent a lot of time around males. This was coded as personality traits within the overarching theme of girls in engineering.

5.3.3.3 Higher reported numbers of females in chemical and mechanical engineering

One girl explained the higher numbers of females in mechanical engineering may be down to using the same skills in very different companies such as moving from a medical company to a car company.

5.3.4 Inherent differences between males and females

The general perception of males were a lot more laid back and didn't think a lot of decisions through by the female students was countered by a lecturer

who said in public that males put on an act but in private, one-on-one, they confessed to being stressed and worried.

5.3.5 Lecturer influence

Half the girls conveyed that the lecturers were a huge part of their enjoyment of their degree citing the small class sizes enabled them to readily access their lecturers when they needed them for help or in one girl's case, advice on whether to stay in a technology course or move to engineering.

5.3.6 Work placement

While some girls lamented the fact that while their course was on a practical level, there was no work placement. Other girls said for themselves and other they knew it cemented their decision whether to stay or leave engineering.

5.3.7 Improving numbers within engineering

While the author was shocked on a personal level that one girl reported there was no real need for anything to be done about the low numbers in engineering.

Other girls while coming up with inventive ideas, it was condensed to raising awareness of civil engineering as a degree choice and dispelling presumptions of engineering as a whole as a male field.

5.3.8 Incentives and programmes for females

There weren't any outright affirmations about any of the girls being involved with any incentives or programmes that supported females in college. One mentioned one she had heard of but wasn't "really sure what it completely entails".

5.4 Thematic Analysis: Stage Two

5.4.1 Higher numbers in transferable industries

The higher numbers in engineering disciplines such as chemical or mechanical may be due to the controllable nature of where girls may choose to place themselves for their careers. Going into mechanics may be suited to girls with a caring nature by entering medical routes such as bio-engineering

where engineers can be seen making an active difference to people's lives. The same can be said for girls in chemical engineering and going into pharmaceuticals.

5.4.2 Seeing themselves as part of particular group and celebrating their differences

The girls seem proud of their position in a male dominated field and this is echoed by one of the lecturers who sees her gender as another tool to use in her career:

> "It's never ever held me back in work. In fact I would say it works in the opposite direction. People tend to remember you. So that gives you an opportunity to build a relationship with people quickly."

The same lecturer was able to negotiate a 4 day work week after having children and credits this to the low number of females in her workplace.

A student expressed that giving your degree extracted the wow factor from people, agreeing with the statement that it had a certain status element to it.

Girls used words such as "odd-ball" and anomaly when describing their differences from other girls.

5.4.3 The burden of children

One girl already stated her intention to either cut down in her engineering career or leave it completely to adjust for having children. The two lecturers were in disagreement over the issue of childcare with one saying that organising childcare in engineering is no different to any other career choice. The other lecturer said it wasn't just an issue of organising childcare but the issue of having to take time out during an important phase of their career.

> "Your twenties are when you establish yourself and get going. Your thirties are when you see people getting promoted very quickly."

The lecturer illustrated her point by giving two female professors as example, one never had children and the other waited until her early forties to have children.

5.5 Thematic Analysis: Stage Three

Extracting three overarching themes from the previous stage resulted in the caring nature of females regarding career and children, personality traits and the social and cultural idea of an engineer.

5.6 Misperceptions by author

From the author's personal perception and experience, the understanding that there are more single sex secondary or post primary schools in Ireland than mixed gender was incorrect. Out of 732 post primary schools in the Republic, there are 490 mixed gender schools making up 66.940% of schools (Department of Education and Skills, 2015). However there are more boys in mixed gender schools at 69.195% than girls at 60.857% (Department of Education and Skills, 2015). While 13 counties had equal numbers of single sex schools for boys and girls, 12 counties had more girls only schools than boys with seven out of the 12 counties having a difference of two or more girls' schools (Department of Education and Skills, 2015).

Even though this was a misperception on the author's behalf, it was echoed by students and lecturers. Two girls reported going to mixed schools while one stated her all girls' background, the remaining three were unclear about their schools. One lecturer verbatim echoed the author in saying mixed schools were among the minority.

In a quantitative study design, a question would have been in place for the participants to select what type of school they attended. Even when asked for details about their background some questions went unanswered.

5.7 Gender breakdown of research paper authors

Out of 41 papers and 104 authors researching women in engineering, 71.154% of authors were female, see **Appendix 7**. However females receiving doctoral degrees in the USA range from 13% in 2008 to 22.9% in 2010 (Smith and Hung, 2008; Leonard and Nicholls, 2013). Which means research on women in engineering, their persistence or reasons for leaving are being researched by a very small group of researchers. As some

participants stated awareness could increase the numbers of females in civil engineering, the lack thereof could be a reason why females do not enter engineering at all. As already stated in the literature review is the idea that girls need to be able to visualise themselves as engineers and this is best done through mentors and role models (DIT, 2012).

6. Discussion

From the thematic analysis, three over-arching themes have emerged from this study; a woman's nature and biological clock steering her towards a caregiving role, the personality type of women in civil engineering and lastly the social and cultural perceptions of women and their traditional roles.

6.1 A woman's caring nature

Among three other reasons why young women in the UK did not enter engineering to begin with was the perception of the possible impediments in balancing a future family with work (Andrews and Clark, 2012). While the two lecturers had opposing views on this, they were established in their career and had already had their children, the informing participant was the student who would give up a career in engineering for children. This shows that the perceptions and preconceived ideas across in the UK are among our own students.

Fouad and Singh (2011) reported 8% of women who never entered an engineering career is currently involved in family care. Reasons these women left included "never planned to enter" at 14.324% and "not flexible enough" at 6.024% (Fouad and Singh, 2011). Is it possible to think that the 6.024% that cited inflexibility as one of their reasons make up a large proportion of those classified as family care? It may be as Fouad and Singh later report that 61% of women cited that managing their work-life balance was a conspicuous barrier. While Fouad and Singh's report was on women leaving engineering, the study that they cited included men as well as women. It would be interesting to see what statistic of men felt they couldn't manage their work-life balance.

As one of the lecturers said she shouldered the responsibility of collecting her young children and adapting her career around them by working from home after she had collected them. She states she is happy with her balance but almost puts the blame on women rather than men for meekly accepting this role that society has always seen women in. Buse, Bilimoria and Perelli

(2013) suggest changing employer for one more flexible and supportive than giving up the industry entirely.

When directly asked, students in Turkey stated that gender is not an influential factor in what disciplines of engineering they chose (Bucak and Kadirgan, 2011). However they did assign disciplines as being more suitable and appropriate for women or men causing Bucak and Kadirgan to state that students were in denial or refused to admit openly. This may have been to dispel Turkey as a less developed country than its European neighbours as discussed by the authors in their introduction. While the participants didn't deny or approve of more gender appropriate disciplines, the comments were there that other disciplines had more females enrolled than in civil engineering.

While research has discussed women leave or not entering engineering because of plans for a family, Cech *et al.*, (2011) found that men with a strong family plans don't enter the industry. This may cast a shadow over arguments that engineering is conducive to balancing family and a career.

6.2 Personality type

Eris, Chachra, Chen, Sheppard, Ludlow, Rosca, Bailey and Toye (2010) reported a higher academic confidence in males than females as well as males reporting that they had confidence that engineering was the right degree for them while the females were overwhelmed. This doesn't hold true for this study as there were more male dropouts than female reported by the participants.

One would think that girls who get into engineering would want to pave the way for others but as one participant said "I don't know if you have to" change the amount of females in the industry. Is this because they value there coveted position as the only girls? Although an older study Gale (1994) echoes of issues today such as females learning to accept sexist language and behaviour that others would not tolerate. Gale concludes by saying that the

females that entered into the industry have a vested interest in maintaining the culture as it is.

6.3 Social and cultural perceptions

6.3.1 Women in STEM

In June 2015, people were astounded by the proclamation of a Nobel Prize winning scientist who said that scientific laboratories should be single sex as three things happen when you have women in a lab: they fall in love with you, you fall in love with them or they cry when you criticise them (Ratcliffe, 2015). This compounds in everyday life that women do not belong in scientific domains. In 2005, the then President of Harvard University made an observation that the inherent differences between men and women is the cause of the low numbers of women in STEM careers (Beasley and Fischer, 2012).

Andrews and Clark (2012) found in their study of teenage girls' perceptions were more strongly shaped by misconceptions and misbeliefs rather than education or experience. This echoes the idea of some of the participants that by the time girls are in secondary school, it may be too late to undo the cultural moulding that has been taking place since birth.

6.3.2 Sexist comments

Sexist remarks, whether joking or intended, do not come from nowhere, society and cultural perceptions and views shape them. Among the sexist remarks heard by the participants "women belong in the kitchen" or the twice quoted "you'll end up as a secretary". All participants reported that these were in jest and that it rolled off most of their backs like "water off a duck's back", however all it takes is one too many comments like this on a stressful and bad day and the stereotype of women crying in STEM will grow, even though it has been the men who come out with these comments who have driven women to their breakpoint in an already busy and often stressful industry.

Having more senior female staff members in the classroom or lecture hall was found to improve male's joking and stereotyping (Creamer, 2012).

6.4 Limitations

As mentioned before the limitations of this study were the small sample size, the time restriction, and the misaligned research philosophy to the author.

6.5 Further research

To further understand why females enter civil engineering and indeed if they are inherently different from men, a nationwide study that includes all years from 1st year up to the graduating class. Including males would give a gender balance to the research something most studies ignore or put to one side. Understanding why students enter engineering in the first place of all genders and years, could increase what needs to be done to retain them in industry once they have left their learning institutions.

7. Conclusion

While on the surface females in civil engineering have many factors pushing them into or pulling them out of industry, the main factors involved in this cohort of participants were the gender roles, personality traits and the caring nature as seen by the higher proportions of females in more transferable industries such as chemical and mechanical engineering. Despite the misconceptions about civil engineering that it is a “boots on the ground” career, the girls that entered the system some years ago and emerged into the industry this year are informed and

8. Recommendations

1. An awareness of civil engineering needs to start in primary school and be maintained right up until the students enters their chosen degree and even then a good lecturer has sway to influence them into civil engineering if they are doubting themselves.

2. Women need to be promoted and celebrated in STEM industries not just civil engineering. Any females in senior positions in learning institutions or organisations need to be acknowledged by the industry and indeed the public.

3. Within engineering courses, lecturers should take time to engage and support the students. An open door policy within reason should be operate especially for females to keep them motivated and engaged in engineering. This will also help the males that put on a show of bravado that lecturers have seen crumble in private.

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Personal learning reflective

This project taught me new skills such as using a different perspective than I have up to now due to the different research method and updated many of my existing skills including time management.

From interviewing, I learnt to listen more than talk, my early transcripts were more conversational than structured. I also learnt that while my

background may be similar to someone else on the surface, does not mean that we hold the same values or desires (such as wanting to work in an office in heels). I also learnt not to assume that just because someone was interested in an area that meant that they intended to go further in their field of supposed interest.

To work in HR, you need to be able to put yourself in someone else's shoes. Understanding that just because you may shake off a comment doesn't mean that it won't bother someone else.

Appendices

Appendix 1: Definitions of diversity

"Acknowledging, understanding, accepting, valuing and celebrating differences among people with respect to age, class, ethnicity, gender, physical and mental ability, race, sexual orientation, spiritual practice and public assistance status" (Esty, *et al.*, 1995; cited in in Green, *et al.*, 2012, pp. 1).

"[The] differences between individuals on any attribute that might lead to the perception that another person is different from self" (Van Knippenberg *et al.*, 2004; cited in Guillaume *et al.*, 2015, pp. 4).

Appendix 2: Email to department heads

Subject: Masters Dissertation on Diversity in Civil Engineering

Dear

I am a student in National College of Ireland undertaking a masters in Human Resources Management. As part of the masters I am required to complete a dissertation. My area of interest is diversity and in particular the number of women in Civil Engineering. On average 20% of undergraduate students are female but only 10% of the work force are female. I intend to look at whether girls intend to go on in the engineering field and if not what is pushing or pulling them away.

For my study I would like to interview a female final year student who completed their undergraduate this year. I would appreciate if you could ask any students if they would be willing to give up an hour of their time at a time and place that would suit them in the next month.

I will follow up this email with a phone call to your office but wanted to introduce myself first.

With sincere thanks

Dorothy Kavanagh

MA HRM

National College of Ireland

[redacted]

Appendix 3: Human Participants Ethical Review Application Form sent to one Head of Department when requested.

Email sent to head of department with Ethical Review Form.

Hi [redacted]

It was lovely to talk to you earlier today. I was onto my supervisor, [redacted], and she was saying that there is no official ethics clearance form but I do have my ethics form that was submitted and cleared by the school's ethics committee. The study has changed slightly since the proposal due to small sample numbers so the ethics form has an online questionnaire instead of interviews. Audio recordings will be used and recorded with a phone and stored on a password protected computer. If you need to confirm any details don't hesitate to contact myself or [redacted] ([redacted]@ncirl.ie or [redacted]).

With thanks
Dorothy Kavanagh

National College of Ireland

Ethical Guidelines and Procedures for Research involving Human Participants

SEPTEMBER 2013

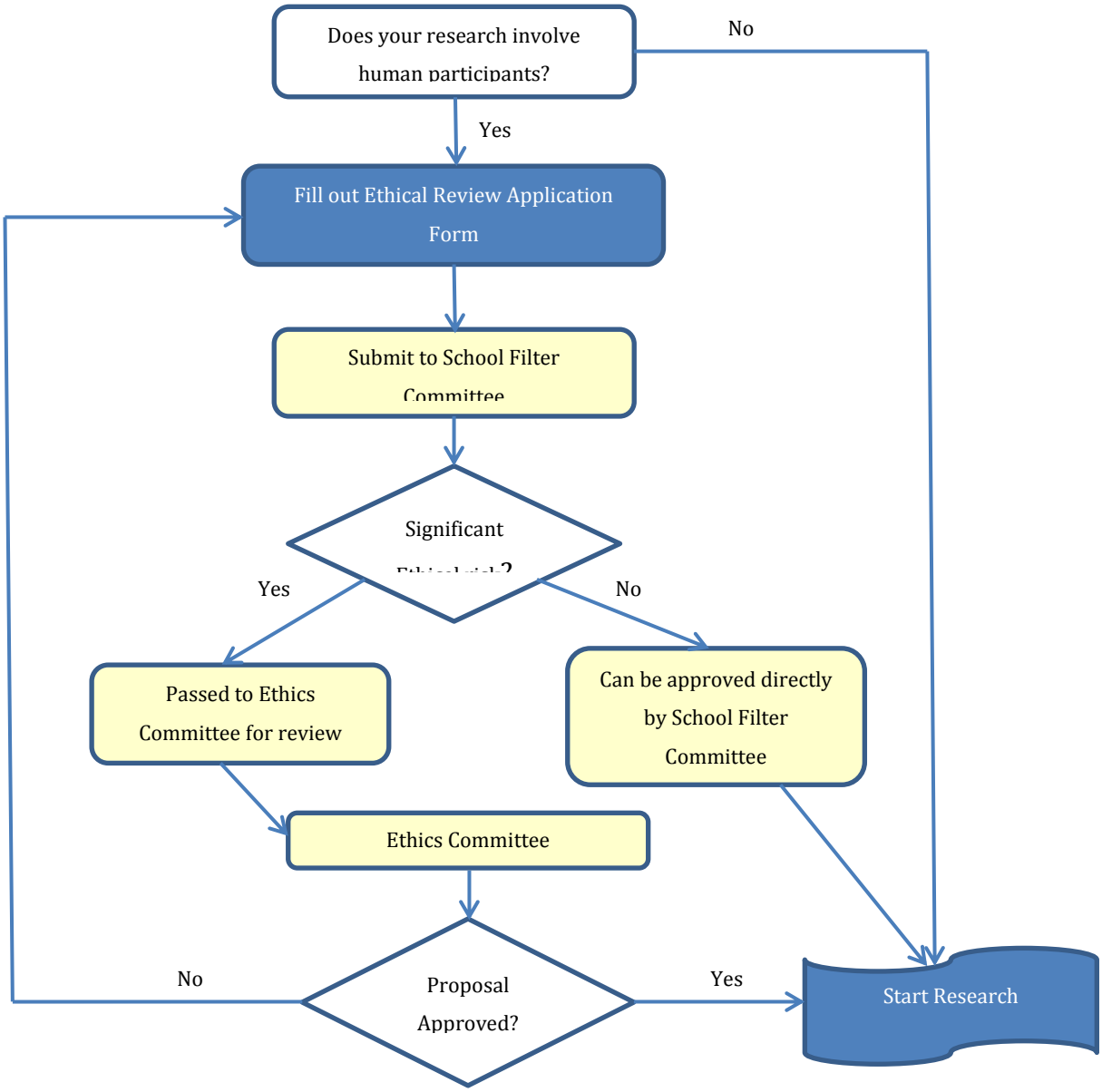

Figure 2: Process chart for seeking Ethical Approval

National College of Ireland

Human Participants Ethical Review Application Form

All parts of the below form must be completed. However in certain cases where sections are not relevant to the proposed study, clearly mark NA in the box provided.

Part C: Ethical Risk

Please identify any ethical issues which will arise and how you will address them.

1. Informed consent of participants
2. Confidentiality of data
3. Debriefing participants

Please indicate any risk of harm or distress to participants.

As this study will address the issue of future careers this may cause worry or panic in students that haven't thought about the future past their final exams. In students that have thought about their career, it may cause doubts about their certainty.

Please indicate how you will address this risk (e.g. debriefing procedures, etc.).

Debriefing post questionnaire with links to institutional career service for anyone that may be worried or concerned.

Do the participants belong to any of the following vulnerable groups?
(Please tick all those involved).

□ Children;
□ The very elderly;
□ People with an intellectual or learning disability
□ Individuals or groups receiving help through the voluntary sector

□ Those in a subordinate position to the researchers such as employees

□ Other groups who might not understand the research and consent process

□ Other vulnerable groups

How will the research participants in this study be selected, approached and recruited?

Students will be contacted by or through their civil engineering department, those that complete the questionnaire fully and give their consent for the data to be used and do not withdraw this consent within the appropriate time frame (30 days) will be used as a participant in the study.

What inclusion or exclusion criteria will be used?

Any student that fails to complete the full questionnaire will be excluded. Male participants will be used for comparison only.

How will participants be informed of the nature of the study and participation?

Through an online information and consent sheet.

What procedures will be used to document the participants' consent to participate?

The online questionnaire will be programmed to exit the questionnaire if the student does not give their consent, participants that do give consent will be reminded of their consent on completion of the questionnaire and that if they want to withdraw their information and answer to email the author's student email address within 30 days.

If vulnerable groups are participating, what special arrangements will be made to deal with issues of informed consent/assent?

As the students are in final year of a three to four year program and the minimum age to enter college is 16 years old, the vast majority of the participants will be 19-20 or older.

Please include copies of any information letters and consent forms with the application.

Part D: Confidentiality and Data Protection

Please indicate the form in which the data will be collected.

□ Identified □ Potentially Identifiable ■ De-Identified

What arrangements are in place to ensure that the identity of participants is protected?

Participants won't have to include any personal identification in the questionnaire beside basic demographics (age, gender etc). Any participants that email to remove their consent, their email addresses will be deleted from an online email server.

Please indicate any recording devices being used to collect data (e.g. audio/video).

N/A

Please describe the procedures for securing specific permission for the use of these recording devices in advance.

N/A

Please indicate the form in which the data will be stored.

□ Identified □ Potentially Identifiable ■ De-Identified

Who will have responsibility for the data generated by the research?

The author will have sole responsibility for the data.

Please describe the procedures of the storage and destruction of data.

The data will be contained in a Microsoft Excel spreadsheet on a password protected personal computer, some hard copy of notes about the data will be kept in the author's house away from other family members or by the author's person. After the study is completed any hard copies of the data will be shredded or destroyed in a similar manner. The soft copy of the data will be kept until completion of the Master's degree and permanently deleted from the author's computer.

Dissemination and Reporting

Please describe how the participants will be informed of dissemination and reporting (e.g. submission for examination, reporting, publications, presentations)?

The participants will be informed that the data will be used for a Master's dissertation and that this dissertation will be available on the Institution's online collection of papers and dissertation but the raw data along with any processed data won't be included in this available dissertation. It is unlikely that any further publication of study will be conducted.

If any dissemination entails the use of audio, video and/or photographic records (including direct quotes), please describe how participants will be informed of this in advance.

N/A

Part E: Signed Declaration

I confirm that I have read the NCI Ethical Guidelines for Research with Human Participants, and agree to abide by them in conducting this research. I also confirm that the information provided on this form is correct.

Signature of Applicant __Dorothy Kavanagh_____

Date __30th of January 2015_____

Signature of Supervisor (where appropriate) _____

Date _____

Appendix 4: Informed Consent Sheet

Informed Consent Sheet

Contact details	Dorothy Kavanagh (MAHRM) dorothy.kavanagh@student.ncirl.ie 0861956622
What is the purpose of this interview?	To collect data on the perspectives and experiences of 2015 female graduates of civil engineering to be analysed as part of a Master's dissertation in Human Resource Management.
What information is the participant expected to give?	Their views, opinions and experiences of completing a civil engineering degree and any future career plans.
How will the information be recorded?	The participant and the interviewer will be recorded using a phone which will be transcribed into interview notes.
How will the information be stored?	The phone recording will be saved onto a password protected personal computer and a backup version saved to a hard drive and/or cloud storage. Copies of the transcription will be in soft and hard format. The soft copies will be stored in a similar manner to the phone recording and the hard copies kept near to the interviewer's person.
Will any of the participants be identifiable?	All participants will be kept anonymous with a short bio such as "Female One is 22 years old, is from an urban background" to distinguish different participants.
What if a participant agrees to be interviewed and doesn't want to be	As transcription is vital to the proper analysis of the recording, no interview will take place.

recorded?

What if a participant agrees to be recorded and then decides to withdraw their consent?	Each participant has 30 days after the interview date to withdraw any information given and the recording and any transcription or analysis will be destroyed.
How long is the recording stored for?	Once the dissertation has been graded and returned, the oral recording will be destroyed including any copies stored remotely.
What happens to the transcription of the recording?	The transcription will be included in the dissertation with any identifying details, such as name, college, town etc, omitted.

To be completed by the research participant:

I confirm that I have read and understood the information in the informed consent sheet relating to this research project. I confirm that I am participating in this research voluntarily and give my consent to be recorded and that recording to be used as academic research in the dissertation. I confirm that I understand I can withdraw from the research project at any time up to 30 days post interview.

Name: ……

Signature: ……

Date: ……

Researcher's signature: ……

Appendix 5: Student interview question sheet

Name: …….. College: …….. Date: ……..

Tell me a bit about yourself?

How have you found studying civil engineering?

What factors influenced your decision to enter the course?

- Was it as you expected?

How do you feel about the ratio of women to men in engineering?

Are there any incentives or support programs encouraging girls to engage with engineering in the college?

- What types of programs are there?
- Did you avail of any of them?
- What is your opinion on them?
- Do the lecturers lend any support?

What were your favourite and least favourite parts of the course?

Have you competed any work placements within or outside college?

Any Transition Year work experience?

What are your intentions regarding a future career? Do you plan to stay within engineering?

- When did you make a decision about this?

Who and/or what influenced your decision?

Where do you see yourself in three or five years' time?

Is there anything else you would like to mention or talk about?

Appendix 6: Lecturer interview question sheet

Name: …… College: …….. Date: ……..

Tell me a bit about yourself and your background.	
How have you found working in civil engineering?	
Why do you think there is such an imbalance in the number of women to men in engineering?	
Are there any incentives or support programs encouraging girls to engage with engineering in the college? What types of programs are there? Do students avail of any of them? Do you think these programmes are effective? What type of support do the lecturers lend towards encouraging students and girls in particular towards careers in engineering?	
What are the general intentions of past and present girls regarding a future career? Do they plan to stay within engineering? When do they generally make a decision about this? Who and/or what influenced these decisions?	
Is there anything else you would like to mention or talk about?	

Appendix 7: Coding system for transcription analysis

Background
Engineering
Engineering background
Background thoughts on engineering
Engineering and personality
Engineering, personality and career/ambition
Engineering course
Engineering future
Girls in engineering courses
Girls in engineering
Engineering courses' future
Girls vs Boys
Sexism
Sexism and personality
Sexism and the future
Improving the number of girls in engineering

Appendix 8: Research paper gender breakdown

Table 5.1: Research papers gender breakdown			
Paper	**Female author(s)**	**Male author(s)**	**Total authors**
Amelink, C. T. and Creamer, E. G. (2010) "Gender differences in elements of the undergraduate experience that influence satisfaction with the engineering major and the intent to pursue engineering as a career".	2	0	2
Amelink, C. T. and Meszaros, P. S. (2011) "A comparison of educational factors promoting or discouraging the intent to remain in engineering by gender".	2	0	2
Andrews, J. E., and Clark, R. P. (2012) "Breaking down barriers: Teenage girls perceptions of engineering as a study and career choice".	Unclear of gender	Unclear of gender	2
Ayre, M., Mills, J. and Gill, J. (2011) "Two Steps Forward, One Step Back: Women in Professional Engineering".	3	0	3
Bagilhole, B., Powell, A., Barnard, S and Dainty, A. (2007) "Researching Cultures in Science, Engineering and Technology: an analysis of current and past literature."	3	1	4

Beasley, M. A. and Fischer, M. J. (2012) "Why they leave: The impact of stereotype threat on the attrition of women and minorities from science, math and engineering majors".	2	0	2
Brawner, C. E., Camacho, M. M., Lord, S. M., Long, R. A. and Ohland, M. W. (2012) "Women in Industrial Engineering: Stereotypes, persistence, and perspectives".	3	2	5
Bucak, S., and Kadirgan, N. (2011) "Influence of gender in choosing a career amongst engineering fields: a survey study from Turkey".	1	1	2
Buse, K. R. and Bilimoria, D. (2014) "Personal vision: enhancing work engagement and the retention of women in the engineering profession".	2	0	2
Buse, K., Bilimoria, D. and Perelli, S. (2013) "Why they stay: women persisting in US engineering careers".	3	0	3
Cech, E., Rubineau, B., Silbey, S. and Seron, C. (2011) "Professional role confidence and gendered persistence in engineering".	3	1	4
Concannon, J. P. and Barrow, L. H. (2010) "Men's and women's intentions to persist in undergraduate engineering degree programs". *Journal of Science Education and Technology*, 19(2): pp.	0	2	2

133 – 145.			
Creamer, E. G. (2012) “Effects of numeric representation of women on interest in engineering as a career”.	1	0	1
Dobson, I. R. (2012) “It’s a man’s world: the academic staff gender disparity in engineering in 21st Century Australia”.	0	1	1
Gale, A. W. (1994) “Women in non-traditional occupations: the construction industry”.	0	1	1
Johnson, P. A. (2013) “State of Women in Civil Engineering in the United States and the Role of ASCE”.	1	0	1
Jones, B. D., Ruff, C. and Paretti, M. C. (2013) “The impact of engineering identification and stereotypes on undergraduate women’s achievement and persistence in engineering”.	2	1	3
Kamphorst, J. C., Adriaan Hofman, W. H., Jansen, E. P. and Terlouw, C. (2015) “Explaining Academic Success in Engineering Degree Programs: Do Female and Male Students Differ?”.	1	3	4
Khazanet, V. L. (1996) “Women in civil engineering and science: it's time for recognition and promotion”.	Unclear of gender	Unclear of gender	1
Laefer, D. F. (2009) “Gender disparity in engineering as a function of	1	0	1

physics enrollment and its implications for civil engineering".			
Leonard, K. M. and Nicholls, G. M. (2013) "History and status of female faculty in civil engineering".	2	0	2
Matusovich, H. M., Streveler, R. A., and Miller, R. L. (2010). Why do students choose engineering? A qualitative, longitudinal investigation of students' motivational values.	2	1	3
McLoughlin, L.A. 2005, "Spotlighting: Emergent Gender Bias in Undergraduate Engineering Education".	1	0	1
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Total authors [1]	74	30	104
Gender percentage of total authors [1]	71.154%	28.846%	[3]

[3] Total authors and percentages exclusive of the three authors of unclear gender.