“Where are all the Irish women engineers: a case study”

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Abstract: In Ireland 2019 there is an obvious lack of female engineers in the workplace. This paper investigates the reasons why this is so and if gender diversity is needed in engineering? A qualitative and quantitative study was carried out and the results discussed. Comparison with international data is made and an analysis of the reasons behind the low figures is offered. Finally, potential solutions to attracting and keeping females engaged in engineering are proposed.

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1. INTRODUCTION

Engineering in Ireland is a predominantly male profession, with only 12% of engineers being female in 2018 according to the professional body, Engineers Ireland. While there have been multiple papers exploring the broader issues, there are few concerning the situation in Ireland alone. International studies have shown that gender balance or women in engineering have been the subject of discussion since the early 20th century (The Military Engineer, 1927), but progress has not matched similar efforts in other professions such as law or medicine. However, some hope is shown in the recent University College Dublin (UCD) study (UCD EGA, 2014), where 26% of engineering undergraduates are female. In this paper, the issues surrounding women in engineering are explored, including why gender diversity is important and useful in the profession, how does Ireland compare to the international situation on gender balance, what changes are needed and how might they be implemented and finally what is currently being done in Ireland to improve diversity in the profession.

2. RESEARCH FOCUS

The focus of this study is to gain an understanding of why girls and young women are not studying engineering at third level and entering the workforce as engineers? Why do graduate engineers from all disciplines not stay working as engineers? It has been the experience of two of the authors that there has been, and is currently, a shortage of female engineers in the Irish workforce. There has been no significant improvement over the past 20 years, and it looks like this will continue into the foreseeable future unless radical changes occur. The following research questions have been raised:

Q1 Why is gender diversity important in the engineering workforce?
Q2 What is the current situation both worldwide and nationally?
Q3 How can change be implemented?
Q4 What is currently being done to improve diversity?

Through searching current literature, and undertaking a short survey, an insight into the national and international trends has been established.

3. BACKGROUND

The World Economic Forum has published a white paper entitled Accelerating Gender Parity in the Fourth Industrial Revolution. It states, ‘women account for 11% of employees in the architecture and engineering job families, a lower share than other related STEM industries including 23% of those related to Information Communication Technology (ICT) and mathematics, and far less than 30% of world’s science researchers.’ The report continues by saying that the small percentage of women in the architecture and engineering fields is primarily due to ‘leaky talent pipelines’. STEM studies attract a smaller number of women in general and there are challenges in retaining the women that do enter. It states that many women move to other sectors within the first five years after graduation. ‘Women account for 20% of engineering graduates, yet only 11% of the engineering workforce. The gap exists in both older industries that employ large numbers of civil and mechanical engineering professionals, such as infrastructure and construction, as well as newer industries such as Information Technology.

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(IT) that employ large numbers of computer engineers.’ Research in the area of gender divide in STEM career participation points to the strong influence of societal stereotypes and implicit biases which influence the self-assessment of women and general negative attitudes in these careers (World Economic Forum, 2017).

4. METHODOLOGY

A mixed model methodology was implemented in this research. Extensive literature research was undertaken from journals, books and the internet. A questionnaire was prepared, and results analysed. It gathered information from female engineering graduates, giving insight into career progression post-graduation.

4.1 Literature review

4.1.1 Why do we want more women in engineering?

At its roots, engineering concerns problem solving. Regardless of the discipline, the engineer is predominately called on to solve a problem, whether this be through design, trouble shooting, research or other avenues. Studies have shown that diverse groups implement better solutions to problems than non-diverse groups (Hong & Page, 2004). A recent book by Caroline Criado Perez (Perez CC, 2019) highlights some of the issues when women are left out of the problem solving and design process. One example is that a woman is 47% more likely to be seriously injured in a car accident than a man, because the safety features were designed by, and for, men. At a very basic level then, there is a case for more women to be involved in engineering at all levels.

Jack Ma, Alibaba founder & CEO, is reported to have said that women are indispensable to his company’s success as both customers and leaders of the company. One quarter of the top roles and one third of the executive board are female. He makes the point that from his experience empowering women is not just fair, but it makes good business sense (Ross, A, 2016)

However, there is a further business case for diversity in functions. Incorporating diverse teams at all levels, leads to more innovation, and consequently better bottom line results. (Stephenson, 2004). Diverse perspectives lead to more rounded decision making, more risks identified and addressed, and so fewer unknown risks are present affecting profits. So, it is a positive addition to any business to ensure teams are diverse, and as such, it will be of benefit to ensure gender diversity and balance exists within engineering teams.

Alec Ross states that as women are half of every nation’s workforce or potential workforce, and, to become, or remain competitive, every nation requires access to the best educated pool of workers. If half of the potential workforce is not available, then that country will not be competitive, and is effectively ‘taking itself out of the game’ (Ross. A, 2016)

Studies have shown (Kanter, 1977) that for a group to appear gender balanced, it needs only contain 35% of the two binary genders. 35% is still a leap from the current 12% of engineers in Ireland being female. That said, UCD reported that 26% of its undergraduates in engineering programs were female, which shows some improvement. However, it is safe to say that few, if any, organisations have a female engineering population approaching 35%. To attract more women into engineering, there must be more visible women working in engineering. This will ensure that the profession is seen as a viable route for all women and not just a select few.

4.1.2 The worldwide snapshot

Table 1 shows the percentage of women engineers working in Ireland as compared to three other countries. Compared to the UK, US and Australia Ireland lags slightly behind but it is in the same order of magnitude. There are reports that Bulgaria, has had success in promoting science and engineering for women, with up to 30% of employees working in science and engineering being female. It is suggested that there is acknowledgement that science and maths school subjects lead to good careers in Bulgaria and all children are encouraged to study these subjects. Equally, Brazil appears to be reaching close to Kanter’s 35%.

<table>
<thead>
<tr>
<th>Country</th>
<th>Year</th>
<th>% women in engineering</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>US</td>
<td>2018</td>
<td>13.84%</td>
<td>Society of Women Engineers US</td>
</tr>
<tr>
<td>Australia</td>
<td>2016</td>
<td>12.40%</td>
<td>THE ENGINEERING PROFESSION A Statistical Overview, Thirteenth Edition Feb 17</td>
</tr>
<tr>
<td>Ireland</td>
<td>2018</td>
<td>11.30%</td>
<td>Engineers Ireland Membership information</td>
</tr>
<tr>
<td>UK</td>
<td>2019</td>
<td>12.00%</td>
<td>Perkins review, Royal Academy of Engineers, UK</td>
</tr>
</tbody>
</table>

4.1.3 Ireland and its story.

The history of women in engineering in Ireland possibly reflects most of Western Europe. Beginning in the early years of the 20th century, women were admitted to engineering programs in universities across Europe, but their numbers were even lower than they are now, approx. 1%. They were apparently looked upon as ‘curiosities’ rather than ‘real’ engineers. Alice Perry is one of the first recognised women to formally graduate from an engineering program in a university, graduating from Queen’s College Galway in 1906. She appears to be following the trend shown in the available
literature of following family influences, with her father being the County Surveyor for Galway and her uncle a member of the Royal Society.

However, post-independence and with a new constitution in place, the place for a woman was seen to be in the home and not in the workplace. This led to very low figures for women in engineering until the later years of 20th century. As mentioned previously a study from the University College Dublin Engineering Graduates Association (UCD EGA, 2014) showed that the numbers of women in engineering undergraduate programs is reaching over 20%, both in UCD itself, and across the country. However, the report states that this has not changed significantly over the last eight years, hovering between 20% and 25%. The figure increases to 27% if all “Engineering, Manufacturing and Construction” courses are included. The gender balance in broader science subjects is consistently much closer to 50%, but this hides inequalities within the sciences, with courses based on biology showing a far greater proportion of female students than physics.

This trend continues when subject choice for the Leaving Certificate (LC is the school-leaving examination in Ireland, typically taken around age 18) is considered. Figure 1 shows the split between male and female students undertaking the Leaving Cert subjects in 2013. It can be seen that, in those subjects traditionally viewed as leading to an engineering degree (excluding biology) female students are very much in the minority. Female students comprised only 4% of the total students taking engineering as a LC subject in 2013.

Anecdotal evidence, collected as part of the survey on women engineers in Ireland, suggests that female students are not always encouraged to pursue careers in engineering. This is partly down to an outdated view of the ‘type of work’ that an engineer does, and a feeling that it is ‘not a job for women’ as it is ‘too dirty’. Careers guidance teachers in schools as late as the early 2000’s, were not aware of the diverse range of careers available within the engineering field. This has led them to focus on heavy industry as the only career opportunity available to engineering graduates.

4.2 Results of the Graduate Engineer’s Survey

A total of 32 women answered the graduate engineer’s survey, having a range of experience, as shown in the Figure 2. The majority of respondents still worked as engineers, with only five having changed careers. Of the five that are no longer working as engineers all are still connected to either engineering or the wider STEM field, pursuing careers in business processes, engineering lecturing, project management and information technology (IT). Only one cited redundancy as a reason for leaving the profession and most indicated a change in interest or a natural progression from their area of interest in engineering.

The results of the survey strongly supported the literature review in terms of the reasons women become engineers. Career prospects came out top of the list at 32%, with school subjects (primarily maths and physics were mentioned) second at 26%. An interest in problem solving, a family member being an engineer and the idea that engineering would be an interesting job were the other reasons stated. When asked for the three best things about being a woman in engineering, the most common response was that it is interesting work, with one third of respondents listing this. Other considerations were meeting other female engineers, job satisfaction, the satisfaction involved in solving a difficult problem and working in teams and making a significant contribution to a project or an issue. A couple of respondents mentioned that it is satisfying to disprove others’ low expectations, but also that certain male colleagues are sometimes more likely to help a female engineer than a male.
Being the only woman was mentioned most often as one of the three worst things about being a female engineer. One respondent reported the sense of achievement when, after some years working with a specific team, she held a meeting in which seven female technical staff were present and no men. She saw this as a milestone in her own career. Standing out, constantly having to prove your knowledge and skill set, not being taken seriously were all mentioned also. Equally, several respondents mentioned that they were being used to “prove” a company’s diversity credentials rather than being chosen for their talent and competency. This makes it more difficult to operate in the workplace, particularly if every decision made is questioned because of the gender of the decision-maker and it is something that almost all respondents mentioned. One respondent reported she has not experienced anything negative because of being a woman, but this was one out of 32. Even incidents like men apologising continuously for bad language was mentioned as a negative thing since it serves to “other” the female engineer and makes it difficult to fit in with the team.

Several women mentioned that lack of flexible working options, childcare requirements or maternity policies were an issue. This was not always because these policies didn’t exist or were inadequate, but sometimes it was down to the woman feeling she was asking for ‘special treatment’ in needing to discuss these issues. It was suggested that women might feel more inclined to pursue a career in engineering if issues like this were resolved at a societal level, rather than at an individual level. This appears to be supported by Metcalf and Afnassieva (2005), who found that as previous socialist states with state-sponsored childcare and a rejection of ‘traditional gender roles’ moved away from socialism, they also moved towards a more traditional view of ‘gendered roles’. With a subsequent reduction in previously state-sponsored supports to people in the workforce, this led to a drop in a previously high proportion of women in managerial and professional roles. Acceptable societal norms facilitate diversity in the workplace.

Even with all the issues mentioned above, all respondents reported they would encourage a young girl to pursue a career in engineering, but with some reservations. The need for a ‘thick skin’, a strong personality and determination were all mentioned as requirements for any woman embarking on an engineering career. But all the respondents also said that the benefits vastly outweigh the difficulties. The diversity of careers, the ability to see things in a unique manner, the excitement of working in fast paced rewarding environments and of determining your own career path were all mentioned as positives. All respondents were very enthusiastic about gaining more gender balance in the profession.

As a final question the survey asked respondents what did they wish they’d known at the time they were choosing their career, that they now know? Several respondents mentioned having to work twice as hard as male colleagues to gain the same recognition or having to shed modesty and develop an ego to ensure that people recognised their work, but overall the response was positive. Some respondents wished they had been better prepared for prejudice in the workplace, or for the lack of basics like the availability of bathrooms in various situations – or at least had some guidance on how to address these issues in a professional manner that still manage to solve the problem.

5. HOW TO BRING ABOUT CHANGE

5.1 The theory of change

Ken Wilber in his book A theory of Everything suggests that human beings through eight general stages of human development. The first six levels are subsistence levels marked by first tier thinking. To shift to the second tier thinking, there is a need for a revolutionary shift in consciousness which can, in turn bring about real change. He says that the factors that facilitate personal transformations are fulfilment, dissonance, insight and opening (Wilber K, 2000).

5.2 Change: past and present

To bring about fulfilment this means that a person needs to be comfortable with a given stage, work or tasks. In terms of women in engineering the educational system needs to facilitate the girls and young women with quality technological education and an insight into potential careers in technology and engineering. If they are not comfortable at this stage then developmental arrest will happen, in other words further transformation is unlikely to happen.

If the young woman has ‘tasted’ and is comfortable with technology, then she is open to transformation. In order for this transformation to actually take place dissonance has to set in. This means she must be dissatisfied with the status quo and she is being pulled in different directions.

To let go of the conventional there must be a pull in the direction of change and insight into the potential of this new adventure. What does this new reality actually offer? How can it change my life? Role models are generally not available to schools but could, at this stage, potentially inform and influence.

Finally, for the change to be complete she needs an opening, a structured path to follow. To take this momentous leap Wilber states that we need “an integral vision and we need an integral practice”.

5.3 Change: future.

The vision previously mentioned helps us to overcome the internal conversations and dissonance. It helps us to look into the possibilities that lie ahead. Integral practice helps us to make sense of the different factors. It takes ideas, notions and anchors them in a concrete manner. This helps push the change into reality and gives us the confidence to move forward into the new situation without fear and evolve into the second tier, the more evolved person.
6. EXEMPLARYS OF POSITIVE INTERVENTION

There is a wave of interventions and movements nationally and internationally to help inform, educate and involve girls and young women into engineering careers and education. Some examples that the authors are engaged in personally are briefly described here.

6.1 Primary and secondary schools

Calmast Ireland was set up in Waterford Institute of Technology’s to promote science and engineering by organising events and activities reaching hundreds of thousands of young people over the past thirty years (Clamast, 2019)

Women In Technology (Waterford Institute of Technology) & IWish are events specifically set up for young women in the senior cycle of secondary education. It brings role models, companies and third level Institutions together to comprehensively explain the opportunities widely available in Ireland in the areas of technology and engineering.

Engineers Ireland STEPS programme is a not for profit strategic outreach programme that promotes an interest and awareness in engineering as a future career to school children through a portfolio of projects (STEPS, 2019).

Big Brother Big Sister – since 1952 the Foróige youth group enables young people to involve themselves consciously and actively in their development and in the development of society. Over 50,000 young people aged 10-18 each year through volunteer-led clubs and staff-led youth projects are engaged. It operates in 26 counties in Ireland, with more than 600 Foróige clubs, 150 youth projects, the Big Brother Big Sister mentoring programme, the Foróige youth entrepreneurship programme, youth citizenship and youth leadership programmes (Froîge, 2019).

Student projects in WIT. Two female students designed a hands-on training module for girls to explain different technological principles such as gear ratio and pneumatics.

Chicktech USA is a not for profit organisation dedicated to increasing the number of women and girls pursuing technology-based careers and retaining women in the technology workforce. In the future the Authors are looking into opening a Chicktech chapter in Ireland (Chicktech, 2019).

6.2 Third level Educational Institutions -Ireland

The design of third level courses with young women in mind (eg chemical, product design and biomedical engineering) has become popular in various third level Institutions in Ireland over the past 30 years.

Ladies coffee morning in WIT has been running for six years now and is an informal way of students and staff connecting and communicating. It has proved very helpful to young engineers by providing a forum for sharing experiences, difficulties and inspirational stories.

6.3 Workplace and Professional Bodies

Engineers Ireland, the professional body of Engineers in Ireland has, since the beginning of 2019 established a new diversity group due to popular demand from its members.

www.wie.ie website – in 2018 Engineers Ireland funded a ‘women in engineering’ project to promote Irish women in engineering. Five women Engineers talk about their role models and influences. They tell of the challenges, excitement, satisfaction and sheer variety of their professional engineering lives as creative product designers, team-builders, project managers, teachers of engineering and structural engineers (Engineers Ireland, 2019).

7. DISCUSSION ON WHAT NEEDS TO BE DONE IN THE FUTURE

In 2017 the World Economic Forum published a report entitled ‘The Future of Jobs: Employment, Skills and Workforce Strategy for the Fourth Industrial Revolution’. They main areas that they recommended to tackle going forward were:

- Combat biases though increasing gender parity in media, film, and advertising.
- Promote business practices that foster gender equality broadly.
- Public policy for families, gender-neutral social safety nets and government-mandated equality standards across all sectors.
- Showcase the public sector as a role model for shifting norms and outcomes (World Economic Forum, 2017).

In real terms in Ireland we need to focus on the continuing to bring positive strong role models to the forefront in tv, films, radio, books as well as in social media Podcasts, Facebook, Snapchat, Instagram, Youtubers and so on. Why not start a Youtube channel on women engineers with interviews, and talks together with Engineers Ireland? This could be linked to the website, as well as being send out to schools as a resource. Let’s forge a connection between engineers and gaming? This could also be established, and might, in a relaxed manner, help bring an understanding of the role of the engineer into everyday life, making it the norm.

Wider subject choice in secondary schools in vital. The exposure to engineering and technology-type subjects will facilitate young women to becoming comfortable in ‘that engineering and STEM zone’, therefore allowing them to consider with confidence engineering careers.

Third level institutions need to look at the curricula and make it more engaging for female students. In 2004 Busch-Vishniac et al stated that ‘there is a certain irony to the need to re-examine the link of engineering curricula to social
relevance, given that engineering is often defined as technical problem solving for the benefit of humankind. Our current curricular structure tends to neglect the importance of social relevance. This neglect is particularly unfortunate for programs that aim to create future leaders, because these leaders will need to understand the social context in which they operate’. (Busch-Vishniac et al, 2004). This should be a matter of urgency for all institutions.

8. CONCLUSIONS

In conclusion it has been established that the shortage of females working in engineering roles is a global challenge and Ireland reflects this shortfall. It is extremely important, going forward, that young women in Ireland recognise engineering as a possible and very worthwhile career. A correlation between the reviewed literature and the graduate survey has been established. In summary the reasons that most of the women who took part in the survey became engineers are: they enjoyed problem solving: they thought engineering would be an interesting career; they had a family member or positive engineer role model in their lives and they enjoyed maths and science in secondary school.

It was also established that working as an engineer is not for the faint hearted. The worst thing about working as a female engineer was, more often than not, being the only female. Additionally, standing out, constantly having to prove your knowledge and skill set and not being taken seriously was also acknowledged.

De Sousa et al states that ‘being a female engineer is not presented as something easy. It requires from the female professional a strong identity with the profession and resilience which makes her stay in business despite the ‘suffering brought by work’. The engineering environment is presented as a workspace that has yet to be conquered by female engineers. The professionals still feel the ‘masculinisation of space’. The female engineers end up creating defence strategies in an attempt to stay competitive, deal with the ‘suffering’ of work, and not give up on their careers. (de Sousa, M.B. and Matos, F.R.N., 2017)

Nonetheless all respondents reported they would encourage young girls to pursue a career in engineering. It is important however that they understand that a strong personality, thick skin, and determination were key to success. They concur that the positives greatly outweigh the negatives. Career diversity, the ability to see things in a unique manner, the excitement of working in a fast-paced rewarding environment and of determining your own career path are very much part of an engineering career. By bringing more gender balance into the profession it will help improve the working environment for everyone.

9. FUTURE RECOMMENDATIONS

Parents, teachers, guidance councillors, positive role models, educational institutes (at all levels) are the influencers of young people when it comes to careers. Continued work in all of these areas is required. Concrete data from primary and secondary schools, both from the teachers and pupils will, in the future, help guide future outreach programmes.

10. REFERENCES