The factors affecting women's advancement in STEM industry in Ireland: A Qualitative Study

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Abstract

In the past half century, women have made significant strides into the workforce, but are still underrepresented in STEM (science, technology, engineering, and mathematics) professions and it is well documented that they do not hold the same number of senior and executive positions as males (Oakley, 2000; Singh and Vinnicombe, 2004). There are significant issues within the STEM industry in retaining and recruiting women with much research and discussion focused on how to solve the "leaky pipeline" that sees a large number of women abandon STEM university courses and STEM careers (Glass et al, 2013; Liben & Coyle, 2014). In the past two decades, a substantial body of research on female underrepresentation has arisen; however, the majority of these studies have focused on educational access and retention, while few have examined the lived realities of women after they have left higher education. This research examines the variety of theories that address the underrepresentation of women in STEM and explore the diverse experiences of women working in STEM fields in Ireland as they moved into leadership positions. We learn, through qualitative analysis of 20 interviews with women that hold senior positions within the Irish STEM industry, what women have experienced, accepted, and learned on their different STEM journey. Our subjects independently reported to have experienced similar cultural prejudices and to have shared similar psychological qualities, despite the reality that these trajectories are typically quite dissimilar.

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Submission of Thesis and Dissertation

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Table of Contents

Introduction

The gender gap in science, technology, engineering and mathematics (STEM) fields is a global concern and an area that has seen a lot of focus over the past three decades but still the problem remains. Gender stereotypes and perceptions of STEM occupations continue to be barriers for women, as evidenced by research highlighting the 'leaky pipeline' (Seymour, 2002). The leaky pipeline is a metaphor used to describe how women tend to drop out of the STEM fields at various periods in their educational and professional careers, often leaving before they have the opportunity to advance to the next level. Cronin and Rogers (1999) conducted research in an effort to identify and characterize the underrepresentation of women in science, engineering, and technology (SET) described the lack of women as 'both progressive (worsening over the course of higher education) and persistent (over time)'.
In Ireland there are approx. 117,800 people employed in STEM related roles but less that 25% of these roles are held by women (CSO, 2021).

According to EIGE (European Institute for Gender Equality) although girls receive better results on average and frequently outnumber boys in university graduates, many of the female students still opt to study courses that lead to a lesser paying career with a lower status (EIGE, 2022). It was also reported that across OECD (Organization for Economic Cooperation and Development) countries, of which Ireland is a member, parents are more inclined to expect their sons, rather than their daughters, to work in a STEM area, even when boys and girls perform equally well in mathematics (OECD, 2015).
In Ireland the gender gap in STEM starts to become more apparent after the junior certificate. Statistics highlighted in the Growing Up in Ireland (GUI) report (Lynch, 2020) show that 72.2% of leaving cert physics positions were held by males, compared to only 27.8% of females.

Some studies show that gender stereotypes and bias against girls begin early in life, making it more difficult for young women to pursue occupations in STEM, which are often viewed as being less feminine (Cho et al., 2009). In Ireland a survey carried out by I Wish found that out of the 2449 teenage participants of their STEM subject survey three quarters (77%) of the teenage girls cited a lack of confidence in their ability in

STEM subject. These experiences of gender bias and stereotyping within STEM along with lack of role models and mentors act as obstacles to females choosing to study STEM or enter a career in STEM and can also have an effect on the retention of women in STEM. Inevitably, the gender gap will persist if only the challenges experienced in STEM are conveyed and highlighted to women, as opposed to the opportunities and prospects.

In a paper published in the Journal of Animal Science the author identifies four crucial stages that determine the retention of women in science. They are listed as early childhood; adolescence, college and graduate school; and the entry into workplace. According to the research, self-esteem, performance, classroom experiences and mentors and advisers have a substantial impact on females during these stages (Pell, 1996). This research will seek to use and expand upon these areas to combine the atmosphere in an Irish workplace alongside the advancement of women's careers into senior roles. This research looks to explore the similar nature of barriers and obstacles for women in STEM and in leadership to determine if these barriers are in fact the same. This study aims to collect useful information from women currently occupying senior STEM positions in Irish STEM businesses, who have overcome the challenges associated with STEM, and to identify the enablers that they believe aided them along their STEM career path.

Literature Review

This research focuses on STEM industries in Ireland and the challenges women face as their careers advance. There will be a discussion regarding the introduction of STEM subjects in secondary schools and the often-used metaphor for the underrepresentation of women in STEM careers, which is the 'leaky pipeline" and describes the points at which females leave STEM – from childhood all the way to STEM leadership roles.

The aim of this qualitative phenomenological study is to examine the lived experiences of women in leadership roles within STEM industries and the challenges they have faced in order to uncover what enabled their journey in STEM. Few studies have directly studied women's viewpoints and bottom-up advancement techniques in male-

dominated fields. The purpose of this research is to try to understand the obstacles and enablers that women have encountered as they pursued leadership positions within STEM industries starting with gender stereotyping and the role of schools and education. Multiple factors may contribute to the underrepresentation of women in STEM fields. Gender stereotyping of STEM careers and roles within STEM as a factor that discourages women along with the lack of role models within the industries. The view point that STEM career paths are not as flexible and have less of a work-life balance than other career paths are all factors that are discussed and investigated.

The research looks to build on previous research such as the perceptions of stereotypes applied to women in STEM (McKinnon and O'Connell, 2020) and the lived experiences of women in Information Technology (Delmont, 2016) and seeks to understand the traits and characteristics of women, as well as the obstacles and enablers they have encountered in their pursuit of leadership positions within STEM industries in Ireland. The research looks to use the individual experiences and narratives to identify the common themes that emerge across women in STEM. Management and leadership were used interchangeably in this study because the literature reviewed did not distinguish between the duties of the leader and manager. Organizational leaders and managers are described as those who have been placed in positions of power and are responsible for dyadic relationships inside the organization (Berkery, Morley, & Tiernan, 2013).

Factors Affecting Women's Advancement in STEM

Perception of STEM and STEM Gender Stereotypes

The creation of gender stereotypes begins at a young age when children are exposed to language and visuals that shape their conceptions of gender roles (Narahara, 1998). Children begin to create comparisons between themselves and others depending on their perceived gender as early as preschool (Renno & Shutts, 2015). As children become increasingly cognizant of their gender, their interactions with adults serve to reinforce gender-stereotyped behaviours (Ruble et al., 2006). It has been established that children as young as two and a half years of age are aware of gender stereotyping

(Miller et al., 2009) and begin to acquire and build their own stereotypes around gender-typed activities, roles, and occupations. A study carried out by Mulvey and Irvin found that children ranging from 3 to 5 years or age held significant gender stereotypes regarding STEM careers (Mulvey and Irvin, 2018). Research carried out in the US at the University of Houston and the University of Washington found that children in first grade assumed that the boys were more interested in engineering than girls, and that by third grade this existed for computer science also (Master, 2022). The study went on to reveal that STEM misconceptions are bigger than STEM aptitude. Girls' interest in STEM are influenced more by the idea that maths and science are less appealing to them than the notion that they may not excel in the subjects. Regardless of how well they perform in scientific or mathematical subjects, girls do not identify with STEM (Sadker, Sadker, & Zittleman, 2009) and do not see themselves in a scientific role in their future career (Baker & Leary, 1995). A large amount of research also demonstrates that children's implicit conceptions about intelligence can set them on vastly diverse motivational and educational paths (Rattan et al., 2015; Dweck, 2015). The development and formation of a person's STEM persona or identity is vastly influenced by their environment and their perception as to whether they believe that they meet the benchmark needed to enter into the STEM community (Vincent-Ruz and Schunn, 2018; Kim et al., 2018). Parents and guardians have been shown to have a significant impact on a child's attitude towards STEM even before they start to attend school and research has further shown that early exposure to STEM related toys, especially engineering, has a direct effect on a student's interest in STEM fields (Maltese and Tai, 2010; Fantz et al., 2011).

Traditional and stereotypical gender norms have stated that girls show more advanced social skills than boys, come across better verbally and are more devoted to children and family (Konrad et al., 2000) whereas boys show higher interest and ability for science and mathematical subject and are more aware and focused on status and financial gain (Diekman et al., 2010). This gender stereotyping has led to the believe that careers within STEM disciplines to be a more natural match for males over females (Cheryan et al., 2013; Hill et al., 2010). The gender imbalance in STEM interest, education, and profession has been linked not to the biological and physiological differences between males and females but to environmental influences that produce and sustain a cultural stereotype positioning that females are intrinsically

less effective in STEM than males (Steinke, 1998). The gender stereotypes surrounding STEM occupations and STEM sectors have significant long-term effects on STEM participation. Gender stereotypes about who will do well in STEM can have a negative impact on women's career decisions and may explain why women who pursue STEM careers ultimately abandon their chosen profession (Cundiff et al., 2013).

Unfortunately, many young people are unaware of the prospects and the vast career opportunities within STEM. Research carried out by Accenture in the UK found that across the UK and Ireland young people are more likely to associate a job in STEM within the following categories: ‘conducting research’ (52%); ‘working in a laboratory’ (47%) and interestingly ‘wearing a white coat’ (47%). This study showed that girls were more likely to make these stereotypical associations that boys (Accenture, 2017). As part of this research 8500 young people, parents and teachers were surveyed and several barriers to girls’ engagement in STEM subjects and careers were uncovered. 36% of young people are discouraged from studying STEM because of their lack of understanding of the careers that STEM will provide and over half of parents (51%) and 43% of teachers felt that pupils lack knowledge and understanding about STEM-related employment opportunities and careers. In addition, the research found that more than half of both parents (52%) and teachers (57%) admit to possessing and displaying subconscious stereotypes about girls and boys in STEM, and more than half of teachers (54%) claim to have witnessed girls leaving STEM subjects at school due mainly to parental pressure.

Gender stereotypes have a negative impact on women's perceived potential and ability (Ellemers, 2018) and in teaching evaluations women faced a negative bias in ratings and were judged on different factors than men, such as looks and personality (Mitchell and Martin, 2018). Female authors receive fewer citations, and data indicates that women are underrepresented as authors in notable publications (Bendels et al., 2018).

STEM Education – The role of schools

The STEM industry is vital to global and Irish economic growth and success and is projected to expand in the future decades. According to the Irish Government report - 2015 Action Plan for Jobs (Department of Enterprise, Trade and Employment, 2015) Ireland hosted:

- 9 out of the top 10 global software companies
- 3 out of the top 5 US games publishers
- All 10 out of the top 10 'born on the internet' companies
- 15 of the top 20 medical technologies companies
- 9 out of the top 10 pharmaceutical companies

All indicating the importance of technology and STEM to the Irish economy.
As discussed, young people's misconceptions about STEM can result in the dismissal of STEM-related jobs and future careers from an early age. Engaging young people in STEM throughout their education is vital and can create opportunities for people while also helping to support and enhance the future STEM community. One of the challenges faced by primary and secondary school teachers has been the lack of guidelines and recommendations for teachers on how to deliver STEM integration strategies into the classroom (Roehrig et al. 2012). In Ireland at primary school level there are 11 mandatory curriculum subjects of which STEM is not one of. All primary schools are mandated to devote 8.5 hours per week to language (Irish and English) and 4.10 hours per week to maths (Hunt, 2011). Science is covered as part of the primary curriculum under the grouping of Social, Environmental and Science Education which also covers history and geography. (National Council for Curriculum and Assessment [NCCA], 1999). Technology or engineering are not covered within the Irish primary education curriculum. Research carried out by McCoy et al. (2012) using the Growing up in Ireland (Lynch, 2020) study, he was able to determine that on average only one hour a week was being allocated to science in the primary curriculum, in comparison to 4 hours for English. It was also reported that there was a link between the teacher's gender and the amount of teaching time spent on maths and science subject with male teachers spending more time on these subjects (McCoy et al., 2012, pp.13–15). This self-selection bias by teachers and the lack of confidence

some teachers have in their ability to teach STEM subject is further evidence that STEM subjects are not getting the attention they need in the current educational system (Delahunty et al., 2021).

While the overall number of students selecting STEM subjects within Ireland on their CAO applications is on the rise, girls' participation remains low. A study carried out by University College of Dublin in 2019 discovered that 40% of boys had listed a STEM course whereas only 19% of girls had (Delaney & Devereux, 2019). The remaining 81% spread across courses in Education, Arts & Humanities; Social Sciences, Journalism, and Information; Business, Administration and Law; Agriculture, Forestry and Fisheries; Health and Welfare and Services. A further report carried out by the European Commission highlighted the growing gap between men's and women's involvement in the digital sector in particular (European Commision, 2022) with four times as many men than women within Information, Communication and Technology (ICT) roles in Europe and a decrease in the number of females taking up ICT higher education compared to that of 2011. The report highlights that in the EU, just 24 of every 1,000 female college graduates are in ICT-related sectors. Only 6 of these 24 graduates end up working in digital jobs. In contrast, out of every 1,000 male graduates, 92 majored in ICT-related disciplines, and 49 of them end up in digital occupations. Research carried out by I Wish, which is an area that is committed to showcasing the power of STEM for young females, highlighted that in 2021 78% of girls still state that they see the lack of subject choices in their schools to be a barrier to pursuing a STEM career in the future (IWish, 2021).

The European Commission state that to achieve gender equality in the digital age, education and training should be one of the main strategies implemented. Therefore, educational institutions, both official and informal, should be regarded as key change stakeholders. Some additional STEM subjects have been added to Irish curriculum and additional forms of teaching from primary to university have been introduced across the EU (Togou et al., 2018). Further strategies and approaches need to be developed and implemented for different age groups, focusing primarily on young girls aged between 12 and 16 and for higher education adoption. Without the support of teacher's students are less likely to consider a career in STEM (Hall et al., 2015).

In 2017, the government in Ireland outlined an ambitious strategy to make Ireland's education and training system the best in Europe by 2026. A STEM education policy statement and implementation plan were essential components of this initiative. Other objectives the Irish government looked to achieve were a 40% increase in the number of females taking STEM subjects in their leaving cert and ensuring that all schools, students, and parents have access to high-quality STEM career information.
The STEM Policy of Ireland is part of the STEM Education Policy Statement and Implementation Plan running over 3 phases from 2017 to 2026. The policy itself is the national strategy of Ireland for the years 2021 to 2026, with the goal of fostering the development of a more involved and digitally savvy society and a highly skilled workforce throughout the country. It also seeks to improve Europe's perception of Ireland as a premier education and training location. Another very important objective of the plan is to facilitate access into STEM careers and to encourage and support the development of computational thinking and digital skills.

Stereotype threat

Popular culture is rife with stereotypes about people who show an interest in moving into STEM industry, creating one of the greatest obstacles for women (Moss-Racusin et al, 2015; Ryan, 2014). Gender stereotypes related to women's abilities and competences within STEM look to further hamper women's futures in STEM careers. Different research has been carried out into women being underrepresented in areas thought to require 'raw intellectual talent' which was described as a level of capability or talent that women are stereotypically less likely to possess than males. Research carried out by Meyer et al. used the field-specific ability belief (FAB) hypothesis to provide evidence that women are typically underrepresented in fields though to need fundamental intellectual talent (Meyer et al., 2015).

As a result of long-standing societal assumptions involving successful white males and academic STEM fields, women now face what is known as stereotype threat. Stereotype threat is a term coined by researchers Claude Steele and Joshua Aronson (Steele and Aronson, 1995) and is a fear or anxiety that one's performance or

behaviour would be viewed through the lens of a negative stereotype (Cheryan et al., 2017; Stamm 2009). Research has shown a connection between this threat and higher levels of stress and anxiety amongst women (Rice et al. 2015) and has been highlighted and documented in women's performance in stereotypically masculine professions (Smyth and Nosek 2015; O'Brien et al. 2015). Stereotype threat has been proven to overall reduce working memory (Schmader & Johns, 2003) which is what people use to concentrate, focus and to perform and complete tasks. If a person's working memory is impaired, it can lead to lower performance and overall results. Therefore, in order to aid women with their performances in STEM, it is imperative to address stereotype threat. Research has shown that social support in the form of role models and mentors has been found to reduce stereotype threat for women and girls (Dasgupta, 2011; Marx & Roman, 2002).

Irish Women in the Workplace

Since the 1970s, women's global economic activity rates have increased considerably because of remarkable changes in the global economy and workforce composition. The situation in Ireland is comparable to that of other nations, with 46% of employed individuals being female. The Global Gender Gap Report illustrates the extent of gender-based inequality and follows their evolution over time. According to the Global Gender Gap report from 2021 (World Economic Forum, 2021) Ireland is ranked 9th in the world in tackling gender gap but it highlights that only 35.3% of senior or managerial roles are held by women, which puts Ireland in 62nd position globally. It also shows that Ireland has a low attainment rate in STEM disciplines, reporting at 14.1% and 5.9% in vocational training, highlighting more must be done to provide women with the skills necessary to succeed in moving into more senior STEM positions.

In order to comprehend modern forms of gender discrimination, it is helpful to consider historical attitudes toward women in the workplace. The Marriage Bar was a policy that was in place in a number of countries, but this research will focus on its role in Ireland. Prior to 1973, women in the Irish civil service were obligated by law to retire

upon marriage. This was known as the Marriage Bar. Lesser work grades were reserved for single women, and pay grades were also determined by marital status. Informally, the Marriage Bar was also observed in the teaching profession and the private sector, and most banks and financial institutes adopted the Marriage Bar. In most areas, it was difficult and rare for women who remained single to advance (Banbrick, 2014).

The adoption of the Marriage Bar in Ireland was motivated by several factors. The "belief" that a woman's place is in the house was one factor and another was to reduce male unemployment and priorities men as the primary income earner ‘one man, one job ‘ (Redmond and Harford, 2010). Numerous studies have examined the beliefs and attitudes of the responsibilities deemed to be suitable and the ‘norm’ for males and females (Eccles, 1987; Corrigall and Konrad, 2007). With traditional gender roles seeing men as the main financial support for the family and women as the caretaker in the home. These beliefs around gender roles are changing with time and education but work-life balance is one of the biggest barriers for women in the work force and to the progression of their careers. The demands of work and family are experienced and handled differently by men and women. Typically, it is women that undertake the majority of the responsibility for family and domestic work while also working outside of the home (Gatrell, 2004) and is often referred to as the ‘second shift’, which was a term coined by Arlie Hochschild in her review of heterosexual couples (Hochschild and Machung 1989). According to studies, women tend to devote more time to family activities than men, although both sexes devote the same number of hours to their jobs (Eby et al., 2005; Friedman and Greenhaus, 2000). Further research has shown that an increasing number of women choose to put their own careers on hold when they have children (Giddens, 1997, Parker, 2015) with several studies across different industries suggesting that motherhood and the decision to have children had negatively impacted or delayed their career progression (Ashcraft, 1999; Reimann and Alfermann, 2018) and resulted in a motherhood wage penalty (Neumark and Korenman 1994; Harkness and Waldfogel, 2003).

Research carried out by Russell and Banks (2011) believe that in Ireland the greatest drop in women’s employment is after their first child, with another significant drop after their third child. Women's traditional roles as main caregivers along with the absence

of affordable childcare for many working parents are factors in this decline. Waldfogel (2007) characterized the influence of motherhood on women's career advancement as the 'penalties of motherhood,' noting that maternity leave or work breaks taken due to family responsibilities cast a 'negative shadow' on women's future careers. Herman and Lewis (2012) evaluated various situations in which women were successful in advancing to senior positions in STEM despite working part time and found that the most important determining factor for these women was a supportive and encouraging management system that made a combination of reduced hours and career advancement a realistic goal. In addition, they emphasized that women who achieve this are the exception rather than the rule.

Work-Life Balance and companies' responses to work life conflict for their employees is an important issue. Policies and practises have been introduced in Ireland to address annual lave, maternity and paternity leave and flexible working hours. These policies are all working towards retaining a quality and skilled work force and to try tackle staff churn. The Irish government have approved the drafting of a new Work Life Balance and Miscellaneous Provisions Bill that looks to hopefully be approved in coming months (Gov.ie, 2022). This bill looks to offer several changes to the legislation to help facilitate better work-life-balance for parents and people who are primary caregivers. This looks to encourage a more equitable distribution of parental leave between men and women, and ultimately to boost the representation of women in the labour market. Several studies have been carried out on organisational factors that affect Work-Life Balance. Johnson (2008) analysed the introduction of WLB programs to help improve employee retention and to help reduce stress and absenteeism. With Grady et al., (2008) reviewing WLB in Irish Organisations and highlighted the benefits of organisations being more flexible and offering childcare facilities and also counselling to help with job satisfaction and retention.

Women in STEM

As already highlighted developments and advancements in STEM are essential for the global economy but also they are driving factors for health and safety. It is believed

that diversifying the STEM workforce will boost creativity, innovation, and the calibre of STEM contributions (Burke, 2007). The COVID-19 pandemic has sped up the adoption of digital technologies by several years and this includes healthcare technologies. Doctors, researchers, and engineers have devised innovative ways to reach patients, diagnose, treat, and track disease, and mass-produce pharmaceuticals, tests, and devices. Many of the recent technological improvements are here to stay, and with them comes an increased demand for STEM professionals. STEM careers and roles will most likely continue to be in high demand going forward as the scope of skills needed evolves and matures.

The role of women in STEM is an important one. The lack of women in STEM roles has caused real life issues and implications for women and society in the past. For instance, women were excluded from clinical trials financed by the NIH prior to 1993, and their later inclusion led to the revelation that women respond differently to several drugs (Clayton and Collins 2014, US General Accounting Office 2001). Women offer unique viewpoints and perspectives which can help with problem solving and resolution of issues. They have the skills and knowledge necessary to challenge assumptions and encourage innovation.

Careers within STEM industries has been viewed traditionally as a male dominated area but as the level of employment of women in the work force has continued to rise since 1925 (Gordon, 2014) studies have shown that women are moving into more male-dominated roles such as IT and achieving excellent results (Valerio, 2009). The ICS (Irish Computer Society) highlighted the challenges being faced in attracting females into STEM related courses with the lack of information on careers and stereotypes surrounding the courses being to blame. According to Adeva IT (Luenendonk, 2020) women only hold 25% of all jobs in the technology industry globally. The gender gap in STEM have been linked to what is known as the ‘confidence gap’. Confidence is a consistent barrier for women at different stages of their educational journey. Pomerantz et al. (2002) reveal that girls, even those who excel academically, experience more emotional strain from self-doubt than boys. There is a large amount of research suggesting that women lack the self-assurance

and self-confidence of their male counterparts, especially in the STEM fields (Madigan et al., 2007; Wolf, 2011).

This problem is not confined to just STEM, but at all stages and in all fields, women exhibit less confidence than males. In 2011 a study carried out by the Institute of Leadership and Management in the UK found that 50% of female managers reported feelings of insecurity and self-doubt compared to less than a third of men (The Institute of Leadership and Management, 2011). The research went on to highlight that for male mangers the level of confidence is recorded at 70% in the 'high to quite high' category whereas it is only at 50% for women. This low self-esteem and confidence and increased levels of self-doubt work together to form barriers for females in their career progression.

Ireland continues to strive to be a world leading centre for technology, science, and engineering. With the development of Dublin's Silicon Docks and the continuous growth of STEM industry employment, Ireland's technical future looks bright. When it comes to recruiting for ICT businesses Ireland has emerged as a worldwide technological hub of choice. As a result, Ireland has been dubbed Europe's ICT hub. The sector employs approximately 37,000 people and generates €35 billion in exports each year. As society adapts to change and the rate of technological advancement quickens, the demand for specialists and innovators in STEM sectors will continue to rise. This means that if Ireland fails to meet this demand, its economic progress could be hampered.

A 2019 report by Engineering Ireland revealed that a worrisome 94% of engineering employees identified a lack of skills as one of the primary obstacles to the industry's growth in Ireland (EngineersIreland, 2019)

This skills gap corresponds to the substantial gender gap in STEM observed in both higher education and within workforce. After the Junior Certificate, nearly equal percentages of boys and girls study science in Ireland, according to Central Statistics Office Ireland (CSO, 2019) but by the Leaving Certificate, girls dominate in both biology and chemistry but are underrepresented in physics. Women continue to dominate the third-level biological sciences but remain underrepresented in physics, mathematics, engineering, and technology. This leads to the 13.9 percent gender pay disparity between women's and men's average hourly gross wages. The below table

shows the representation of females from junior certificate up to and including STEM roles in Ireland.

Statistic	Source
48 % of 2018 Junior Cert Science candidates were female	(CSO, 2019)
In 2018 for every 9 girls that sat Leaving Certificate Biology there was one who sat Physics	(CSO, 2019)
Women only represented 18% of engineering graduated in Ireland in 2018	(Engineers Ireland, 2019)
In 2004 the percentage of women as ICT specialists stood at 30%, this dropped to 21% in 2017 and this dropped again to 19.1 % in 2021	(Eurostat, 2021)
Women only represent 12% of female engineers in Ireland.	(Engineers Ireland, 2022)
25% of STEM roles in Ireland are performed by women	(CSO, 2021)
13.9 % lower average hourly pay for women vs men in Ireland in 2014	(Eurostat, 2019)

Table 1 – Representation of females in STEM by numbers (WITSIreland, 2022)

Diversity is a key driver for innovation. According to research, every industry benefits from diversity, not just to maximize individual opportunities but also to meet economic demands (Roberge and Van Dick, 2010). This is also true for STEM teams in the workforce, since they require a variety of perspectives. This diversity can be attained by ensuring that each group consists of members of various genders, races, cultures, ethnicities, nationalities, etc. A study carried out by Proceedings of the National Academy of Sciences (PNAS) found that a group of diverse problem solvers will out-perform a group of high ability problem solvers (PNAS, 2004). According to a study

conducted by Scientific American (Philips, 2014) stated that variety and diversity make people more innovative, conscientious, creative and hard-working, alters how people approach and how people think, and ultimately aids in making us smarter. These qualities and characteristics that individuals can cultivate and utilize through diversity are crucial to the STEM field. Diversity is essential for new discoveries, innovation, and unique views points.

There is a common assumption that female role models help to increase women's confidence and their beliefs in their ability to be successful in STEM. Research carried out by Cheryan et al. (2011) looked to answer the question ' Do Female and Male Role Models Who Embody STEM Stereotypes Hinder
Women's Anticipated Success in STEM?' Their results found that role models in STEM, whether they were male or female, who lived up to stereotypes that aren't in line with the female gender role hurt women's confidence in their ability to do well in STEM but didn't affect men's confidence. Other research has shown that female role models help to protect women who look to enter or are already involved in STEM against the negative stereotypes and their harmful effects (Marx & Roman, 2002; Stout et al., 2011). This research looks to investigate if role models have in fact acted as an enabler for our interviewees in their lived experience.

According to the EIGE (European Institute of Gender Equality, 2018) only 1% of girls on average reported that they saw themselves working in ICT related employment compared to 10% of boys. Globally there is a large gender gap in STEM roles, at both university and labour force level. A report carried out by STEM Education Review Group of Ireland highlighted a considerable drop in internes in STEM subject at leaving cert level, especially by women (Gov.ie, 2016).

There are approx. 117,800 people in Ireland who work in STEM-related jobs. According to the Central Statistics Office, the Expert Group on Future Skills Needs and Forfás, there will be an estimated 44,500 job opportunities for people with high-level information and communications technology (ICT) skills in Ireland during the next six years. Without action on the gender gap there within the STEM industry there is a high probability that these positions will go empty.

Mentorship and Role Models

There have been numerous studies carried out to try and understand what helps the academic performance and retention of women in STEM. 'Its hard to be what you can't see' were words used by Marian Wright Edelman in her call for a more diversified portrayal of children of colour in literature and educational materials (Wright Edelman, M. 2015) and these words will ring true for female leaders within STEM. Role models are vital to younger children in their developmental learning stage as children see themselves in others. For students that show an interest in STEM exposure to role models in these subjects can sustain their enthusiasm and improve the possibility that they will innovate in the future. Students' ability to see themselves in a role or course has more of an impact in their choice of course selection and enrolment in STEM that their ability (Godwin et al., 2016). Identifying with a role or a feeling of belonging is linked with retention and perseverance (Tonso, 2014) and a lack of belonging and an absence of role models has been cited as a common reason for attrition from STEM college courses and from STEM careers (Lichtenstein et al., 2014). Women within STEM already struggle against negative stereotypes that cause them to doubt their own abilities within the area (Spencer, Steele, & Quinn, 1999; Settles, 2014). Female role models that can be strongly linked with STEM help to protect and support against such negative stereotypes (Stout et al., 2011). Research and studies carried out by Microsoft shows that interaction between real-world STEM professionals in the form or mentors and role models have a huge and positive impact on girls and their interest in STEM (Microsoft, 2022). The word mentor can mean different things to different people (Kram, 1985). A mentor or mentoring can take the form of career guidance; friendship; a source of information and academic guidance (Sands et al., 1991) with Sambunjak et al. (2006) describing mentorship as having an 'important influence on personal development, career guidance, career choice, and productivity". Role models and mentors are most effective when they are on different levels to that of their mentee, this is known as the stepping-stone model (Roberts, Kassianidou, & Irani, 2002) and having a mentor that is also a leader can work to provide a more positive outcome (Settles, 2014).

Women role models in STEM enhance young women's attitudes and self-perceptions and boost their ability to consider STEM professions as a career path (Cheryan et al., 2011; Corbett and Hill, 2015). Mentoring can be in many forms, from formal mentorship to informal, peer to peer and group mentorship and has been acknowledged as an influential mechanism in the professional growth of the mentee who views the mentor as a role model, which is a factor connected with effective and successful professional development (Ibarra, 1999). Research has shown that women value mentorship more than men and that they benefit more in terms of professional development, and yet surprisingly women are less likely to have a mentor at the early stages of their careers (Cross et al., 2019).

Research carried out in 2017 in the US identified that students of colour are more likely to graduate high school if they have at least one black teacher between third and fifth grade. The research highlighted that this is due to the fact that when students can relate to their teachers during their school years, they feel more confident in their ability and capacity to succeed (Gershenson, Lindsay, & Papageorge, 2017). Although this study focused on the particular relationship between teachers and people of colour the overall findings can be applied to minority groups and within that is women in STEM. It puts a spotlight on how detrimental it is to students and young impressionable people when they are in a classroom and there is no one there that is like them, whether that be colour or gender. Therefore, young women that see and interact with members of the STEM field that look like they look, and they can relate to it, make STEM careers a more attainable and achievable goal. Mentorship programs can help to show that not only is there a place at the table for women in STEM but that being at the table will ensure that the next generation of STEM professionals will be a more accurate reflection of the world.

Workplace mentoring can take the form of a formal organisational program or one that is created through an admiration of a potential mentee and a possible mentor (Kram, 1985). Organisations are aware of the important benefits of mentoring as a way of using existing talent to help develop new talent and have tried to mimic the spontaneous and informal mentoring model with a more formal mentoring approach (Geiger-DuMond & Boyle, 1995; Murray, 1991, Vance et al., 2017). Informal mentoring occurs more organically than formal mentoring, which is typically fostered through a

structured mentoring program. The duration of formal mentoring relationships is typically shorter than that of informal relationships (Douglas, 1997). The belief that a close one-on-one developmental relationship between a senior, more knowledgeable and experience individual, whom would be the mentor, and a junior or less experienced individual whom would be the mentee, is an important and valuable career development experience (Kram 1985). Previous research has stated that informal mentoring is more beneficial to the mentee than formal mentoring (Cotton and Ragins, 1999; Singh et al., 2002; Bynum, 2015) with mentees being happier and more satisfied with their mentors. Searby et al. reported from a mentoring study carried out with female participants that the majority of positive mentoring relationships were both informal and also intentional (Searby et al., 2015). Mentors also benefit from the mentor-mentee relationship with Kram (1985) stated that by being a mentor you are growing a loyal base of supports which can in turn help the mentors job performance. Mullen (1994) suggested that being an organisational mentor would help to give valuable insight into the organisation.

Mentoring-embracing organizations are rewarded with increased employee engagement, retention, and expertise. (Benson et al., 2002). Successful mentorship of women has been found to reduce feelings of loneliness and promote self-confidence, inclusion, and a promoted more work engagement. (Dutta et al., 2011; Varkey et al., 2012). Comparison of people with and without mentoring experience has highlighted traits such as self-awareness, sociable and achievement orientated that are more likely to seek out mentoring or take part in mentoring programs (Underhill, 2006; Kammeyer-Mueller & Judge 2008). Some research reported that although there has been extensive discussion and research into the mentorship of women and minority groups, and their access to mentors, it has highlighted that there is little evidence that gender or race are linked to the experience of being a mentee (Kammeyer-Mueller & Judge 2008, O'Brien et al., 2017). Other research found that the most important factor was the quality of the relationship, but some pointed out that mentorships between people of the same gender can be helpful because they share similar interests and life experiences (Lin et al., 2021).

Women's leadership style

As discussed, there has been a large amount of research carried out on the lack of gender equality in the STEM industry. Similarity, there has been a great deal of research carried out on the lack of equality between men and women in leadership positions but there is a lack of research into the connection between these areas. Applebaum et al., (2003) reference in their report that research has highlighted few differences in the natural abilities of female and male managers, however, there is a persistent belief that women are less capable leaders than men. Other theorists such as Helgesen (1990) and Claes (1999) suggested that a woman's inherent femininity gives her an edge in leadership roles. Traits such as enhanced communication skills, empathy, conflict resolution and negotiation skills and a 'soft' approach to managing people were characterises described as essentially feminine (Bernay, Cantor and Stoess, 1992). In order to be considered a leader, one must have the ability and willingness to influence others to reach a common goal as defined by Northhouse (2001).

Claes goes on to state that a new set of values, referred to as feminine values, began to be seen within business and these values contrasted with the traditional masculine management principles, such as competition and authority. There has been much research into leadership styles with the most frequently referenced being that of by James MacGregor Burns (1978) who proposed there were 3 styles: transactional leaders, transformational leaders, and laissez-faire leaders. Traditionally male leaders would have shown transactional leadership style in the form of supervision, rewards and punishing and clear chain on command, but a different style of leadership, transformational leadership, have proven to be a more effective type of leadership style when leading people (Eagly et al., 2003). This style of leadership promotes innovation, encourages, and motivates while providing support and coaching and it has been said that transformational leadership style is likely to be exhibited more by women (Guadagno and Cialdini, 2007). Other studies have provided evidence of more positive outcomes related to transformation leadership such as that of Judge and

Piccolo (2004) and evidence presented by Yammarino et al.(1993) highlighted a connection between people's performance and transformation leadership. Empathy has been identified as one of the main factors associated with transformational leadership along with emotional intelligence (Rubini, 2017) and helps leaders to improve communication and relationships with employees (Rosete and Ciarrochi, 2005).

Leadership style has been found to be a significant factor in helping both men and women move up the career ladder (Vinkenburg et el., 2011) with other people arguing that the underrepresentation of women in senior leadership roles is due to their leadership style (Hoyt & Murphy, 2016). The other argument that has been made is that many women simply don't aspire to be leaders and do not want to move into leadership roles, although this may be the case for some women, as it is for men, as quoted by Hannum et al.,(2015) 'there are women who desire to be senior leaders and have the skills to do so, but face multiple challenges on their journey to the top". Continuous development of employees provides a competitive advantage and contributes to the success of an organization; therefore, it should be a priority for a business. (Hopkins et al., 2008). Organisation needs to take into account that men and women differ when it comes to leadership styles. Effective training programs have been shown to improve leader-related outcomes by 7% - 18% (Hopkins et al., 2008) and prior research by Hopkins et al. (2006) suggested that the availability of training courses to develop skills and further education was one of the most commonly mentioned methods for developing leadership skills.

Women and Leadership in STEM

Examining the literature on the challenges women face in leadership finds a strikingly similar theme to that of women in STEM. Eagly and Carli (2007) suggest that the 'glass ceiling' metaphor is no longer accurate and that a labyrinth is a more accurate metaphor for the challenges women confront. A succession of complexity, detours, dead ends, and unexpected paths, as described by Eagly. Women have shown that they can break through the 'glass ceiling' as they hold leadership roles but the labyrinth is a more apt metaphor for the number of detours, dead ends, and unique paths that women and members of minority groups experience in many organizations, which serve as barriers to achieving the highest positions of leadership. Discrimination and

sexual harassment were some of the major problems and barriers faced by women in the late 19th century and early 20th century (Gornick 1990; Rossiter 1982,) and although these have lessened, they still exist. Terms such as the ‘old boys club’ and ‘chilly climate’ were some of the barrier’s women reported on experiencing when trying to advance in male dominated career fields.

The focus of research has shifted from women's intentional exclusion to "second-generation" forms of gender bias as the fundamental cause of women's chronic underrepresentation in leadership roles. Cultural assumptions and organizational structures, practices, and patterns of interaction that mistakenly favour men while putting women at a disadvantage result in the creation of significant, yet subtle, and frequently invisible barriers for women. First generation bias refers to the deliberate and visible behaviours of discrimination against women in the workplace or within society, second generation bias are said to be concealed and somewhat invisible and have a more ‘neutral’ appearance, but the fundamental beliefs and practices are noticeably male-orientated. The second-generation gender bias is linked to the inability of women to be accepted as leaders or move into more senior roles within an organization. (Grover, 2015)

Researchers (Blackburn, 2017; Wynn & Correll, 2018) claim that gender bias, along with intolerant and chilly cultures, lack of mentors and mentorship programmes, insufficient Work-Life Balance (WLB) policies all attribute to the challenges and barriers women in STEM careers and leadership positions face. Women in leadership positions have stated the substantial personal costs of occupying a senior leadership role (Loeffen, 2016).

When a leader deviates from the gender-based expectations it has been seen to cause issues. Research carried out by Catalyst (Catalyst, 2018) showed how gender stereotypes create a ‘no-win’ situation for women in leadership roles. An example give is where a man takes charge of a situation, they are likely to be seen as strong, decisive and assertive, where as a woman that takes charge is viewed as a competent leader but disliked.

So what are the implications of these obstacles for women looking to progress their careers in STEM industries and what enablers will help them to advance? Women aspiring to hold leadership positions within the STEM fields face difficulties within the field itself but also, for some, in reaching the level of seniority they aspire to achieve. As senior positions, mentorship, and key networks continue to be lacking for women in STEM areas, additional effort is required to safeguard their growth in these fields. (O'Connor, O'Hagan, & Gray, 2018).

Research Question

Secretary-General António Guterres, UN Chief, announced in February of 2021 that 'Advancing gender equality in science and technology is essential for building a better future.' In Ireland we can see that this issue is being addressed through policies and government plans, but women are still underrepresented in senior and executive managerial roles within the STEM sector. In 2021 the Minister for Further and Higher Education, Research, Innovate and Science Simon Harris highlighted that more than half the STEM companies in Ireland are finding it extremely difficult to recruit staff in IT and engineering. He highlighted the criticality of addressing the shortage of talent in these key areas such as STEM for Ireland post pandemic economic recovery. The gender gap in engineering is undeniable. Engineering Ireland confirmed that of 16% of engineering graduates are female, with females only being accountable for 12% of all engineering professionals in Ireland (Engineeringireland, 2022). Some of the worlds leading technology and science firms have operations in Ireland and manufacturing and supply chain accounts for 32% of Irelands GDP – this is significantly higher than the European average of 15% (IDA, 2020). Reducing the gender gap in STEM in Ireland could assist in closing the skills gap and promoting economic growth.

The underrepresentation of females in STEM has been a topic of research over the past two decade and this study looks to build on previous research with a focus on not only the barriers encountered but the enablers that helped women be successful in their careers in STEM. Studies carried out by Dasgupta and Stout (2014) focused on the obstacles to STEM encountered by females through their 3 main developmental stages – childhood, adolescence, and emerging adulthood. Research carried out by

(Figueroa and Hurtado, 2013) looked to understand the challenges that students faced specifically during their graduate programs in STEM. Additional research into barriers and enablers for women's career enhancement in areas outside of STEM, such as higher education institutes (Mahershwari and Nayak, 2020) and also in different cultures (Mate, McDonald and Do, 2018) is important information to gather to help understand what is needed to help women progress towards and occupy leadership positions.

The purpose of this study is to understand the obstacles and barriers faced by women in their careers within the STEM environment in Ireland and explore strategies that were used through their successful advancement in a bid to find common themes. Understanding the factors that affect, both positively and negatively, the career advancement of females in STEM may also aid in reducing the gender gap in STEM. This research looks to provide information to current and future women of STEM on the factors that may influence their careers. The outcomes of this research will look to offer perspective to discussions around gender misrepresentation in STEM industry and the retention of women in STEM. This research will help aid the understanding of the factors that may impact women's decisions to pursue a career in STEM and may assist and improve STEM companies' retention and promotion of females. This study's participants consisted of female leaders who hold senior management or higher positions within STEM industries in Ireland.

The following research question guided the interview process:

What do the lived experiences of our interviewees suggest about the relevance and importance of barriers and enablers for Irish female professionals within the STEM industries.

The objectives of the research are as follows:

- To explore the factors that influenced the participants into a career in STEM.
- To identify the barriers and enablers the participants encountered throughout their career.

- Recommend changes or strategies that can be put in place to help reduce the gender gap in senior STEM roles in Ireland.

Hypotheses

There are two hypotheses proposed for this research.

1. There are common barriers that women in STEM face as they move into senior positions within the STEM industry.
2. There are common enablers that women have experienced which have helped them in their career as they moved into more senior roles.

Although previous studies and research has been carried out in the US and across Europe, there has been little research that documents the lived experiences of women in senior roles in STEM industries in Ireland. This research will help to fill that research gap. This research looks to support previous studies and we expect to prove that within Ireland the perception of women and women's interests still has a negative effect on females' enrolment in STEM subjects. We also expect to find the lack of subject choices for Irish females in schools to be a major barrier to females moving into a career in this area. We also look to show the importance of mentors and roles models to females in their careers within STEM and in their advancement to senior positions.

Research Methodology

For this research we conducted interviews to study the lived experiences of women in senior positions with STEM industries in Ireland, taking into account the existing literature available. Our interview questions were designed to trace the STEM education and career path of our interviewees, to highlight their early objectives and interests, and to document and record examples of barriers and enablers they encountered.

This study aims to build on the research that has already been carried out in this area and help to better understand the challenges faced by women within the STEM industry and the factors that aided them as their career progressed. It is critical for

companies to have a clear understanding of these issues if they hope to expand the number of women in leadership positions.

Interview Questions

The interview questions, listed in Appendix A, was based on previous research as discussed in the literature review. The questions were designed for women who currently hold senior roles within STEM industries in Ireland.

Questions were constructed to separate out childhood and school experiences from those of the participants working and leadership experiences and to differentiate between the barriers encountered and the factors that assisted them through their career.
The interview questions were broken down into themes influenced by research carried out in the US in relation to barrier and assistance for female leaders in academic STEM (McCullough, 2020) and a study carried out on the factors affecting women in STEM in Australia (Prieto-Rodriguez et al, 2022).

Using these themes helped to structure the research questions and using Braun & Clarkes (2006) 6-step framework the researcher was able to analyse the data to identify sub themes. Table 2 is an illustration of the how the data was categories and the percentage of participants that mentioned the sub-theme.

Themes	Sub Themes	Theme Description	Number of participants mentioning this theme one or more times (%)
Gender stereotypes & Bias	Perception and Unconscious Bias	Beliefs, attitudes, and assumptions made	
	Childhood and School Experiences	Experiences of stereotyping as a child or in school	
	Lack of awareness and understanding of STEM	Understanding of competencies and what is needed to develop interest in STEM	
	Lack of Female Role Models	Lack of same sex role models had on gender-stereotypical ability.	

Gendered Workplace	Harassment	Inappropriate behaviour, direct or indirect, verbal or physical, experienced in the workplace.
	Lack of representation in senior roles, mentors, and cheerleaders.	Effect of lack of female mentors and role models in senior roles within the workplace

Table 2 – Themes and Sub-Themes

Research approach

The study employs a qualitative and phenomenology approach to identify factors that affect women's advancement with the STEM industry. Qualitative research focuses on the lived experience in an effort to understand and provide meaning to the experiences that people have. Qualitative research is defined as "the systematic collection, organization, and interpretation of textual material derived from talk or conversation. It is used in the exploration of meanings of social phenomena as experienced by individuals themselves, in their natural context" (Malterud, 2001). An exploratory interpretive qualitative approach will be the research approach used for this study as the goal of the study is to explore the experiences and understand the main challenges women face in their journey to leadership roles within the STEM industry. Participants are able to explain in their own words what is fundamental and crucial to their experience in qualitative research (Van den Hoonaard, 2015). Interviews help to get a deeper understanding of the participants lived experience and can provide a 'window to the past' (Weiss, 1995) and lived experience, in contrast to immediate experience and pre-reflection, refers to an experience that has been lived.

Phenomenology is an approach to qualitative research that focuses on peoples experience and looks to find a commonality within a particular group. Phenomenological research allows the researcher to investigate the phenomenon from the perspectives and viewpoints of the participants. (Moustakas, 1994; Marshall and Rossman, 2006). Using this approach will help the researcher to understand the lived experiences of the participants through interviews and review of case studies and the challenges they faced when aspiring to leadership positions and what

opportunities assisted them. While qualitative research questions are initially outlined, they are also fluid and subject to change based on the data collection process; thus, a specific technique cannot be guaranteed. The same holds true for data gathering methods; interview questions may be outlined ahead of time, but the precise questions asked of participants may vary depending on perspective or answer to previous questions (Bogdan & Biklen, 2007). Due to the fact that the majority of qualitative research designs entail acquiring information from specific individuals, participant anonymity cannot be guaranteed; however, confidentiality can be maintained (Hennink, Hutter, & Bailey, 2010).

The researcher used an approach called the ‘responsive interviewing’ approach when carrying out the interviews with the participants. The approach was proposed by Herbert and Irene Rubin (2011) and this interviewing technique is focused on a conversational partnership between the interviewer and the interviewee. This strategy allows the researcher to generate meaning from the participant's words and stories in order to comprehend their experiences. This approach comes with the view that the interview is more of a conversation that an interview and allows for the interviewer to pose unscripted questions to promote more insight and reflection. Individual interviews are, according to Hatch (2002), the primary source of data collecting for phenomenological studies.

The interview technique adopted included three categories of questions: primary questions, follow-up questions, and probing. The primary questions were aimed to focus on the main topic of the research issue and address the main research question the probing and follow-up questions helped to add depth and detail into the answers and seek additional explanations.

McCullough carried out similar research with female leaders in academic roles in STEM in the US (McCullough, 2020) and similar research carried out by Woo on pre-career barriers and enables to women in STEM (Woo, 2019) This researcher will look to build on this research but focus more on women in senior and executive roles within Ireland that have already progressed in their careers and discuss the challenges they faced.

Participants Selection and Data Collection

The participants in this study will be 20 women who currently hold senior positions in STEM fields either within academia or industry. Through targeted recruitment of women working in STEM, we adopted a snowball sampling method, reaching out via email within our STEM networks and recruiting by word of mouth without a "sample frame" in order to achieve interconnection (Creswell, 2013; Check and Schutt, 2012, p.105). All 20 participants took part in the one-to-one semi-structured interviews and while each of the interviewees were allowed the freedom to discuss and express their opinions and perspectives throughout the interview process, the interviews were directed and guided using the open-ended questions listed above.

Interviews were carried out remotely over Teams between May 2022 and July 2022 and were structured into 3 sections discussing (1) childhood ambitions; (2) their viewpoints and experience of equal opportunity in STEM, and (3) what factors assisted or hampered their advancement in the STEM field and their encounters with barrier and also enablers throughout their career. The interview questions were based on relevant prior literature and the identification of topics we wished to investigate among a sample of women in STEM. As mentioned earlier, a semi structured interview approach was used for the data gathering. Semi-structured interviews are similar to structured interviews in that the themes or questions to be asked are arranged in advance, but open-ended questions are used instead of closed ones (Owen, 2014). Individual interviews were deemed to be more appropriate than group interviews or focus groups as some of the topics discussed were of a sensitive and personal nature.

The duration of the interview times ranged from 30 minutes to 65 minutes. The interview questions were emailed to the interviewees several days prior to the interview to give them the opportunity to read over and review the questions. They were also informed of the anonymity of their answers. This research focuses on the third portion of the interview, but also considers how childhood aspirations and perceptions of opportunity can influence STEM-related career pathways. Interviews were recorded and the researcher also took notes.

Anonymising data

In this research, anonymization played an important role. Participants revealed private and sensitive information about themselves and third parties. The participants discussed matters that impacted them personally and professionally. Each of the interviewers was informed that the data would be anonymized so that the participants could not be identified. The most frequently used form of anonymisation of research data is the assignment of pseudonyms (Clark, 2006). For this research each participant was assigned a different letter of the alphabet based on the sequence and timing of the interview e.g. Interviewee B, Interviewee C as shown in the table 3 below:

Pseudonym	Discipline	Role	Years of Service
Interviewee A	Technology	Senior Technical Sales Engineer	15
Interviewee B	Engineering	Senior Mechanical Engineer	17
Interviewee C	Engineering	Principal Engineer	30
Interviewee D	Technology/Science	Analytical Science & Technology Lead	15
Interviewee E	Science	Executive Director	35
Interviewee F	Science	Sr Process Sciences Specialist	22
Interviewee G	Science/Mathematics	Senior Analyst	12
Interviewee H	Engineering	Senior Chemical Engineer	15
Interviewee I	Engineering	Director	22
Interviewee J	Technology	Director of Cloud Operations	17
Interviewee K	Technology	Senior Data Analyst	22
Interviewee L	Technology	Chief Customer Officer	25
Interviewee M	Science	Head of Data Science	19
Interviewee N	Engineering	Senior Manufacturing Engineer	15
Interviewee O	Technology	Senior Program Manager	20
Interviewee P	Technology	VP of PMO	31
Interviewee Q	Engineering	Head of Cloud Engineering	38
Interviewee R	Technology	Senior Project Manager	16
Interviewee S	Technology	Senior Cloud Architect	24
Interviewee T	Mathematics	Senior Research Analyst	19

Table 3 – List of Participants

Following the interviews, the recordings were transcribed and de identified. It has been highlighted that there is no transcription process that can provide a flawlessly representation of the original information (Kowal and O'Connell, 2014, pp. 65–66). In an effort to address this and ensure the accuracy of the information gathered and to validate the transcript each transcript was sent to each interviewee to review and edit

if needed. Some interviewees added additional information to the original text and all participants sent back a signed off and validated version.

Transcriptions of interviews and field notes were evaluated using a content analysis method involving coding and recoding. The researcher reviewed and read through all transcripts and notes taken to highlight and identify the key points and ensure a clear understanding of each of the interviewee's narratives and answers. The initial coding was then changed, categorized, and put into several themes.

Limitations:

This research had the following limitations:

- The participant pool consists of only 20 participants across a number of senior roles within the STEM industry in Ireland, so the results are not reflective of the entire Irish population.
- The survey only contains participants that were willing to participate in the research.
- Some factors may not have been discussed by any of the participants as they may not have been considered important or relevant by the interviewees. Future studies and research would be needed to identify and highlight these factors.
- The participants were not taken from different geographical areas of Ireland but more so from the major cities.
- As the interviewees were all in senior roles the mean age of the participants was 47.5 years old as the ages ranged from 34 to 60.
- This research did not have many participants from the mathematics discipline.

Assumptions:

Assumptions that were made by the researcher were as follows:

- Each participant had an interest from school years in STEM subject or a career in STEM industry.
- That there would be certain common themes across the participants lived experiences.

Qualitative Coding

Qualitative coding is the practice of categorizing qualitative data into groups in order to find patterns and themes within the data. The purpose of qualitative data analysis is to identify the categories, linkages, assumptions and beliefs that shape the respondents' perspective of life in general, but focusing on the topic they are discussing in particular (McCracken, 1988)
Coding and categorising of the data is an imperative step in the data analysis, and it involves creating categories, subdividing the data and assigned the data to these categories (Dey, 1993).

A code is, at its most fundamental level, a label or tag that describes the content of a piece of text or data gathered during the study. These codes can have a straightforward tag or description or can be more complex in the form of a metaphor or analogy (Miles and Huberman, 1994). The function of coding, according to Seidel and Kelle (1995), is to identify significant phenomena, gather examples of these occurrences, then analyse these phenomena to determine similarities, differences, patterns, and structures. Using thematic analysis this researcher was able to read and review the data gathered and identify these patterns and similarities experienced by the interviewees. Thematic analysis is a technique for examining qualitative data that involves searching over a data collection to identify, examine, and report recurring patterns (Braun and Clarke 2006). This technique is known for its flexibility when being applied to a wide range of questions and was identified as a approach particularly suited to phenomenology (Joffe, 2011). Numerous researchers have published

numerous guides on how to conduct thematic analysis (Attride-Stirling 2001; Joffe 2011), but for this research and data analysis, the researcher will follow Braun & Clarks' (2006) 6 step framework, which has become the most widely used method among qualitative researchers (Clarke and Braun, 2017).

Braun & Clarke (2006) six-step framework for undertaking this type of study is outlined in the below table 4:

Phase	Steps Carried out
1. Familiarising oneself with the data	Transcribing data; reading and re-reading; noting down initial codes
2. Generating initial codes	Coding interesting features of the data in a systematic fashion across the data-set, collating data relevant to each code
3. Searching for the themes	Collating codes into potential themes, gathering all data relevant to each potential theme
4. Involved reviewing the themes	Checking if the themes work in relation to the coded extracts and the entire data-set; generate a thematic 'map'
5. Defining and naming themes	Ongoing analysis to refine the specifics of each theme; generation of clear names for each theme
6. Producing the report	Final opportunity for analysis selecting appropriate extracts; discussion of the analysis; relate back to research question or literature; produce report

Table 4 - Source - Six-step thematic analysis procedure – Braun & Clarke (2006)

Data gathered for this research was divided into themes and subthemes. Themes can be defined as a 'patterned response or meaning' (Braun and Clarke 2006, p. 82) that is obtained from the research question or study. They are broad data categories shared across the participants of a study or interviewees. The data that is collected within that theme, labelled sub themes in this research, is related to the overall theme and gives context and tells a story about that theme. The use of thematic analysis enables us to understand the different elements and dimensions of a phenomenon

that the interviewee describes and the different connections between the events and the themes. The full list of themes and subthemes can be found in Appendix B

Analysis and Findings

Factors that affecting women's career path:

Women in STEM industries are significantly more likely to report gender-based discrimination on the job than men in comparable positions. The women in this study mentioned discrimination as one of the main reasons why there are not enough women working in STEM professions. Women in STEM roles are more likely than men to believe that their gender has harmed their success and to highlight a number of concerns, including discrepancies in pay and unfair treatment from co-workers based on gender stereotypes. The themes that were linked with barriers to women's career progression and sub-themes identified among the women interviewed are discussed below: The participants also described the different areas that were enablers and support factors that helped them throughout their career, such as mentors and supportive family. Both areas will be reviewed in this next section.

Barriers

Gender Stereotypes & Bias:

Perception and unconscious bias

Several of the participants interviewed for this report mentioned the 'social norm' around the type of people that work in STEM, and as mentioned earlier in our research that social norm in STEM industry is predominately white males.

Additional comments discussed by the interviewees was the assumption that the males in their family or extended families would be more interested in engineering and technology that the females. As highlighted in the literature review, there have been a number of studies carried out that back this misconception up, Interviewee G stated that *'I was encouraged to pursue a career and a college course in the 'soft science' subjects like biology and medicine, but the 'harder science' subjects were more*

appropriate for males and that was something I had heard from an early age so I did start to believe it'. This aligns with the research carried out by Master (2021) that states that the perception that boys are more interested in engineering and computer or 'harder sciences' can start as early as six.

Social Bias was another reason given for there being fewer women in STEM then men. Interviewee C mentioned how when she told her parents she wanted to study engineering she was told '*that is a job for a man and is no place for women'* and although the interviewee does state that this was over 40 years ago and a very dated comment and not something that *'would not be socially acceptable to say now, it was my experience, and it shaped my STEM journey'*. Interviewee C went on to give examples of the unconscious bias she experienced during her career as an engineer *'I had to prove myself over and over again to my peers and my manager, compared to my white, male colleagues. I had to fight harder than the men to lead projects, even when past projects were a success, and work three times as hard to get the same level of respect and recognition as my male colleagues'* (Interviewee C).

Other interviewees mentioned how other females perceived STEM subjects and STEM careers using aid they couldn't see themselves in STEM roles as they didn't have a '*technical mind and couldn't code'*. The perception that careers in STEM would lead to a career or simply coding or research was commented on by a number of interviewees. *'I had a love for physics and maths, they were my favourite classes in school. When I spoke about college and courses that would allow me to further develop these skills there would be a lot of talk about research positions and lecturing, none of which I wanted to do. Luckily, I continued with these subjects and now have a role I love in chemical engineering'* (Interviewee H). These findings align with those of the research carried out by Accenture. (Accenture, 2017)

Childhood and School Experiences

Much research has shown how stereotypes impact children from a young age, with results showing that children believed that boys were more interested in STEM subjects than girls and how this could be linked to gender stereotyping from a very young age. Interviewee A described how she remembers getting toys such as toy

kitchens and dolls to play with while her brothers received junior science kits as '*they were the typical types of jobs they would have when they grew up' (Interviewee A).*

Several interviews highlighted the lack of knowledge and information in schools around STEM college courses and STEM careers and this has been highlighted throughout our research as one of the barriers females face. A number of participants attended all-girls secondary schools, and teaching, nursing, and medicine were the most encouraged college degrees for students with excellent test scores. College courses in computers and technology were not generally discussed, and there was a lack of understanding regarding the potential occupations and careers resulting from these courses. If they intended to enter this field, students were responsible for acquiring this information.

'*Technical Graphics was a subject I was very interested in and heard about it through a male friend as it was available in their school, no course like that was available to us in the all-girls school that I attended so I had to try find a course I could attend outside of school which I also had to pay for. The teachers within my school were not able to give me any guidance in the STEM areas I was interested in'* (Interviewee D). This correlates with the findings of Roehrig et al. (2012) in regards the lack of guidelines available to teachers on how to deliver STEM in the classroom and also highlighted by the findings of McCoy et al (2012) and Delahunty et al., (2021) who raised the issue of the lack of priority given to STEM subjects in primary schools and some secondary schools and the effect of self-selection bias by teachers.

Lack of Awareness and understanding of STEM

Several interviewees didn't study STEM in college and moved into the area through different roles. Interviewee L studied Applied Languages in college and went on to do a postgraduate in marketing and PR. '*There was a lack of awareness as to what your career could look like if you studied subjects within the STEM remit and the diversity of careers paths available'*. She went on to say '*there was no link between the courses, but I had always enjoyed maths in school and was very good at physics but the options around careers in STEM were not discussed when I moved into Leaving Certificate' (Interviewee L).*

Interviewee G commented that '*in the all-girl school I attended subjects like applied maths and mechanical engineering were not offered but were offered in the boys school' (Interviewee G).*

Unfortunately, current research and studies have shown that is still an issue today as highlighted by IWish (2021).

Lack of Female Role Models

As highlighted in earlier in this study the lack of female role models and mentors in STEM leaves women within the industry and women interested in entering the field without the incentive to pursue STEM-related activities and careers.

'*As a student in college I remember seeing many of my male peers looking to male mentors to fill a variety of different roles and provide them with advice, I didn't have the same availability of female mentors available to me and often caused me to consider leaving the course.'* (Interviewee G).

It was a common statement across many of the interviewees that female role models and mentors were very much lacking in their schools and universities and aligns with the research by Tonso (2014) that being able to identify with a role model helps people feel like they belong. Interviewee L who did not study STEM in university said that '*if I had a mentor and role model within the STEM industry to highlight the different career options within the industry then I do believe I would have studied a STEM subject in college or a course that would have directed my career into STEM earlier on.'*

'I found myself constantly questioning my ability because I began to believe that I didn't belong in STEM. There were no mentors or role models for me to turn to that could help support me with that self-doubt' (Interviewee S). These comments from the interviewees correspond to the research carried out by Lichtenstein et al. (2014) and Spencer et al. (1999)

'*Movies like Hidden Figures that told the story of the fantastic black women working in STEM in NASA that helped to shape American history, are such important stories to tell. Women have not been recognised or represented correctly in STEM literature, and some have been eliminated completely. This is now changing but we need to continue to highlight and publish the contributions from women'* (Interviewee K).

Gendered Workplace

Harassment

Unfortunately, there were a number of interviewees that highlighted harassment as one of the obstacles they encountered throughout their career in STEM, and one they believe contributes to the under representation of women in STEM. Although it is not as accepted or as common as it has been in the past it continues to plague women in STEM.

Interviewee J described how she had to put up with sexual remarks from male co-workers about her clothing and her body shape and when she told them to stop was told '*if you want to be one of the boys you have to act like one of the boys'* (Interviewee J). Interviewee F discussed how she was taken off a project when she reported a co-worker constantly asking her out on a date. '*I asked why I was removed from the project I was told that it was obvious I wasn't able to work in that male environment and it would be easier to move me to another project than to bring HR into the picture'* (Interviewee F).

Interviewee P described how she was told on a call with a male stakeholder that '*if I knew you were a woman, I wouldn't have waited to hear your opinion*' (Interviewee P).

Lack of representation in senior roles, mentors, and cheerleaders.

As discussed earlier, research has shown the importance of cheerleaders and mentors with the STEM industry. Interviewee D discussed how the lack of mentors and role models within her organisation impacted on women applying for more senior roles in a bid to progress their career stating that '*women didn't want to go for senior roles when there was no female leadership as it was not worth putting your neck on the line when you knew the push back you would get'*. She went on to say that many talented women had left STEM due to '*every day being a fight where your skills were constantly being challenged*' (Interviewee D). This again confirms the research carried out by Tonso (2014) that linked retention and role models and the research by Marx and Roman (2002) and Stout et al. (2011) that highlighted how female role models in STEM help to protect and support other females in STEM.

Stereotype threat, as earlier defined, is where an individual feels at risk of confirming a negative stereotype about a group that one belongs. Research has shown that paring young female students with female role models help to prevent and erase

stereotype threat. Interviewee A stated that '*I truly believe that I would not have struggled as much with my role and position within the IT industry if I saw more female role models. What I now know to be stereotype threat led me to believe that if I didn't do well, I would be letting all of the women in IT down as I would be confirming the society's stereotype that women are not tech savvy'* (Interviewee A).

Internal Barriers and expectations of women

Confidence

Several interviewees cited lack of confidence as an obstacle they faced throughout college and their careers. This lack of confidence was particularly frequent when they were the only or one of few women at a lecture, in a lab situation or in meetings.
Interviewee D commented that it was '*very intimidating when you are in a lab with such a low female to male ratio'* (Interviewee D). This interviewee stated that in her first year of a 4 year course in Information Technology in a University in Ireland there were 20 female students in the course compared to 160 males. By the end of the course there were only 12 females left and 155 males. These comments and these statistics backup the continued need for support for female students in STEM. The results here align with the research carried out in relation to the leaky pipeline in STEM (Jakobs, 2022; Almukhambetova et al., 2021)

For some of the interviewees it was the confidence to speak up for themselves when disputing a decision or pushing back against gender-based job assignments that they found to be obstacles. A number of interviewees described being made to feel disregarded or underappreciated in the workplace. Interviewee B described how she was requested to "take the notes" in meetings even though there was a more junior male co-worker in attendance. Interviewee R described *'at the start of a meeting with an external senior stakeholder I was instructed by one of the male senior managers to go make everyone a coffee. I remember feeling so embarrassed and didn't have the confidence to say that wasn't my role. I consequently missed a significant chunk of the discussion, including my opportunity to be introduced to the stakeholders and felt excluded for the rest of the meeting.*'(Interviewee R).
Many of the interviewees stated men dominated meetings and continuously challenged their decisions. Conversational dominance was a term used by 50% of the participants when describing how men would behave in meetings. Interviewee L

described how she had to work twice as hard as her male colleagues as her decisions on specific technical decisions was constantly challenged in meetings, '*I had to be data driven and have all my facts in place and ready or my opinions and decisions would be challenged and possibly rejected, much more so that other males in the meeting'*, (Interviewee L) she went on to say how important it is for women to speak up in meetings, '*it's not enough to have a seat at the table, which you probably had to fight to get, you now need to speak up confidently and make your presence known'* (Interviewee L). The above statements from the participants aligns with the research and findings from the Institute of Leadership and Management mentioned in the literature review (The Institute of leadership & Management, 2011)

Self-promotion

A number of interviewees emphasized visibility when describing the things that helped the participants of this study earn promotions or advance their careers. Visibility of work achieved, goals met, deals won, and successes made. The issue was that only a small percentage of the women interviewed felt comfortable with self-promotion and majority of women are reluctant to share their accomplishments. Many interviewees mentioned the backlash of self-promoting and that other females can be some of the harshest judgers. *'Women are so easily labelled as full of themselves and arrogant if they talk themselves up, and women are judged more harshly than men for self-promotion because it challenges the cultural expectation. Women are not expected to be assertive and confident and when they show that they are they can face backlash for it'* (Interviewee E). Other phrases and comments made through different interviews were how self-promotion felt 'alien and uncomfortable' (Interviewee O) and how it can '*make a person come across as though they have an ego, and it isn't the nicest trait'* (Interviewee S). These results confirm the findings in relation to women trying to progress into leadership roles highlighted by Catalyst (2018), that call out women are in a no-win situation when they try to take charge of a situation.

Family Life, Motherhood, and the Invisible Load

90% of the women interviewed mentioned children, motherhood, the 'second shift' or 'invisible load' when asked about barriers for women in STEM. Motherhood has a direct effect on women's careers with interviewee E stating that '*motherhood leads to a devaluation of women's abilities and leads to a denial of certain opportunities.'* The 'motherhood penalty' is a term that was used by several the interviewees and the stereotypical view that mothers are less productive and capable once they have children. Interviewee B commented that *'it can be very difficult for women to advance in their careers once they become mothers, firstly you have to take a career break and then try to step back into a career or area that has moved on, you are already feel like you are on the back foot'* (Interviewee B).

90% of the participants that have children said they bore the sole responsibility for organising their families' everyday tasks and schedules. They discuss the 'second shift' of work that they face when they finish their job, and all have admitted to breaking down in tears due to the stress. This is in line with previous research carried out by Gatrell (2004) who highlighted that the majority of family and household responsibilities are carried out by women, who also work outside the home.

'*The home is seen as the woman domain and with that comes most of the responsibilities for the children. Remembering their after-school activities and ensuring they have everything going out to school, planning the lunches and the weekly dinners all falls to me. I am a senior programme manager in work but when i come home I still have to continue managing all of the family tasks'* (Interviewee K)

These stresses and responsibilities were heightened during Covid with women having to carry out the tasks of their first shift (their paying job) and their second shift (motherhood and family tasks) in parallel. Lack of support and lack of work life balance saw many women leaving their jobs during the pandemic. Interviewee F candidly stated, '*you can't hand in your notice to motherhood and sometimes something has to give, and it has to be your career*'.

'A nine to five or even an eight to six working day would be a dream come true. My day starts at 6 and doesn't finish until 8.30 in the evening when the kids have finished their school work and then I may get an hour to myself before its time for bed and it starts all over again. It leads to stress, not only at home but also at work.' (Interviewee M). These findings are also highlighted by the research carried out by Eby et al. (2005).

Another very common situation that women face is being asked about childcare. '*I have been at work events or overnights and asked 'who is looking after your son?'. A man is never asked about his childcare arrangement'* (Interviewee L).
These finds are consistent with what has been stated in previous research (Giddens, 1997, Parker, 2015; Reimann and Alfermann, 2018).

Leadership style

This theme appeared as a barrier to some interviewees and as an enabler to others so is listed in both areas of the findings. Interviewee J said it is '*very hard for women in senior and manager roles to strike the correct balance without being seen as too tough or too meek, and you feel forced to try balance respect with likability'*. The 'double bind' where women are supposed to be warm and caring but also competent and challenging is something their male counterparts do not face. This has been highlighted in the research carried out by Hoyt and Murphy (2016) who stated that the lack of women in leadership was in fact due to their leadership style. Interviewee M spoke about a project that she was managing and how her perseverance and drive led to a really successful project but the outcome also damaged her personal brand and she received negative feedback '*I looked to implement new processes across a program of applications and were rolling this out as a project. I knew these processes would work even when I was getting push back, I kept going and kept pushing the agenda. When the project was completed, it was a huge success and improved so many areas of the department, but I received feedback that I was pushy and arrogant. I do not believe I would ever have received such feedback if I was a man* ' (Interviewee M). These results go to strengthen the findings of Grover (2015) that calls out the second-generation gender bias that women face where women who act assertively are often perceived as too aggressive and shows an inability of women to be accepted as leaders within an organization. Another example of how a leadership style was more of a barrier than an enabler is when women focus too heavily on meeting the needs of others over their own. Interviewee E describes how she openly shared a lot of information within the team in a bid to build relationships and trust but was left feeling '*taken advantage of and foolish' (Interviewee E)* when it wasn't reciprocated, and her information was used by others to promote themselves.

Enablers:

Mentoring and Role Models

To climb the corporate ladder, individuals look to sponsors and mentors to help them identify and achieve opportunities and foster leadership development. There are numerous barriers between entry-level roles and senior or C-suite opportunities, but sponsorship and mentor ship has been shown to assist individuals overcome these obstacles.

Teachers

As discussed, research has shown that students that able to relate and communicate better with their teachers are more likely to feel secure in what they are capable of doing and trusting their ability to succeed. Interviewee C explains how a teacher of hers convinced her parents to allow her to put an engineering course as her first choice on her CAO application.

'*My parents had hoped that I would follow in my mother's footsteps and become a teacher, but I always had a natural curiosity about how things worked from an early age and had been interested in the idea of engineering all through my school years.. My parents were concerned about these types of courses as they were unsure of the future job opportunities, my physics teacher stepped in and explained the various options available, as well as the possible career paths that would be available. It really was due to the support of this teacher that I was able to include these course on my CAO form'*. (Interviewee C)

These findings highlight the importance of teachers understanding and promotion of STEM within schools from an early age. This further emphasises the importance of the research and findings called out by McCoy et al (2012) and Delahunty et al.,(2021) in relation to lack of priority of STEM and the effect of self-selection bias by teachers.

Role Models and Mentors

Interviewee J spoke about the impact a mentor had on her within her role as a manager and how this female mentor helped her to move up the career ladder to a role as a director.

'*She was such a support and someone I still stay in contact with, I admired her leadership style when she started in the company and approached her for mentorship.*

She agreed and helped me work through issues and doubts I was having of my own capabilities; she was very honest and encouraging. She was fundamental in my career as I could see that she was not only good at her job, but she was excellent at motivating and transferring that passion for what she was trying to achieve, it was contagious and inspiring' (Interviewee J). These results lie with that found but Settles (2014) who stated that mentors that were also leaders facilitated a more positive outcome for women in STEM and also with Searby et al. (2015) who concluded that mentoring that was informal but intentional led to the most positive mentoring experiences.

Spontaneous mentors seemed to provide a greater experience and benefit that officially designated mentors with interviewee L discussing how she felt a mentor that was assigned to her as part of a workplace program was a '*tick the box'* exercise and more of a '*chore than a positive and developmental process'* (Interviewee L).

A similar experience was discussed with Interviewee D who said she reached out to a member of the senior board and asked her to be a mentor.

'*We had a mentor program in the company I was in but I found the mentor assigned to me just didn't share similar managerial styles or interests and it was hard to find common ground. The mentorship experience with the new mentor was much more positive as we had mutual interests and shared developmental books and podcasts and it was easier to communicate and share information'* (Interviewee D). These results ties well with previous studies mentioned in the literature review highlighting the benefits of informal mentorship (Cotton and Ragins, 1999; Singh et al., 2002; Bynum, 2015)

All interviewees that had an overall positive experience through their mentorship relationships and are currently mentoring or have been a mentor in the past.

When asked about gender in mentors 80% of the interviewees said they preferred same gender mentors. 60% had experience with male mentors and although they said it was a positive experience, they found that with spontaneous mentors they naturally reached out to female mentors. Again, the common response across all interviewees was that although they normally gravitated towards female mentors, they did say that the quality of the mentorship is the most important aspect and all interviewees would be open to a mentor of the opposite sex. These results were in line with previous finding (Lin et al, 2021).

Support network

Family

A supportive family is something that was a common thread across a number of the interviews. Parents that told their daughters that they '*could be anything they wanted to be'* (Interviewee I) and '*achieve anything they put their minds to'* (Interviewee A) Interviewee J spoke about her mother had to give up her job when she got married was very supportive of her daughters.

'*She would drive us to get additional grinds in maths every Saturday so we could keep doing well in honours maths as we needed those extra points in the leaving cert'*. (Interviewee J)

Interviewee L spoke about the importance of a supportive life partner. '*It is important that you choose a life partner who shares your vision and is prepare to work with you investing the time needed for a path to leadership'* (Interviewee L).

Workplace

Improvement in Work Life Balance (WLB) in the workplace was highlighted as a major benefit and enabler for female careers. Flexible working hours and introducing of shared parental leave policies helped females with families to balance their work and life responsibilities. Businesses with a reputation for promoting work-life balance have become an extremely desirable place to work.

'*Being able to log on earlier and then finish earlier meant that I was able to collect the kids from school and my husband dropped them off. I was able to put in a full day in work but then still be available for my kids when they came home from school.'* (Interviewee I). These finding correlate with that of Grady et al., (2008) who identified flexibility as one of the WLB strategies that needed to be implemented by organisations to improve job satisfaction and employee retention.

The continued drive for gender equity in the workplace is an important and influential factor. Buy in from senior leaders and C-Suite level is crucial in implementing an

inclusive leadership approach. '*Diversity is good for business and a workplace that levels the playing field and helps to empower women is better placed to solve the problems of the future with more women on board*' (Interviewee F).

Development opportunities are what are needed in a bid to retain and support employees. For Interviewee L she described how the inclusion on a Leadership Development program gave her the confidence and the skill set she needed to excel in her current role as a manager and also apply and be successful in getting a more senior position within the company. '*The course helped me to examine my perception of my leadership skills and align my skills with my organisations culture. It gave me the tools to see the success factors and the 'de-railers' that I faced and how to address both. The course taught me how to be a credible and powerful leader and the company allowed me the time to attend this course and the support I needed'* (Interviewee L).

'*Our company ran a number of networking and developmental sessions for people that looked to move into leadership roles. These were mostly run after work or at weekends. The company noticed that it was majority attended by male employees and they decided to send out a survey asking what they could do to improve these. Women with children simply couldn't attend as they didn't have the time with their family responsibilities, so they changed these sessions to lunch time sessions and the female attendance went up 80%.*' (Interviewee B)

On-line

Every participant in this research was a member of some women in STEM online community with each of them mentioning the benefits they have gained from these global networks. Interviewee D spoke about how these online platforms have helped grow her network and given such support since she joined. '*The ability to connect with other women in these fields who have gone through similar experiences and are facing similar obstacles is such a valuable source of support'* (Interviewee D)

Formal leadership training

100% of the participants in the survey had engaged in some formal leadership training throughout their career and 80% of the participants still participated in leadership programs as a mentor or a guest speaker. Interviewee K stated that '*leadership development and training is important for everyone but especially women due to their underrepresentation at more senior levels within organisations'*. She went on to say that too often women are too busy looking after others, whether it be family, or teams and '*women need to invest in themselves and participating in leadership training will help to develop the skill set needed to take the next step up the career ladder'* (Interviewee K).

'I have participated in many leadership & coaching programs over my career, Each program had a corporate focus and changed across employers. My advice to females that are looking to move into more senior roles would be to put yourself forward for leadership training or seek this out yourself if not offered within your company, you can learn on the job but formal training can help to fill any gaps'. (Interviewee P).

Overall these findings are in accordance with findings reported by Hopkins et al. (2008) that highlight the positive effects of continuous development of employees and how effective training programs can improve leader-related outcomes.

Ability, Determination and Passion

Interest

Interest and '*a love of fixing things'* was some of the reasons behind being drawn in to engineering and science subjects as described by Interviewee C. A 'logical' brain was how one of the interviewees described herself, '*maths and physics made sense to me and I loved going to the classe*s' (Interviewee C).

'*As a child I loved jigsaws and lego and the utter heartbreak I felt when I realised that my school didn't run any of the woodwork or metal work classes that my brothers were able to avail of. I didn't have any interest in home economics, I wanted to pull things apart and figure out how to put them all back together'* (Interviewee N). She went on to find out what courses in college would allow her to follow her passion and then worked on getting the points to get into those courses. Interest as an enabler for women in STEM is something that needs to be protected against from gender

stereotyping and gender bias. As highlighted in the work carried out by Mulvey & Irvin (2018) who reported stereotyping emerging at young as three and five.

Capability

Women have been found to be more agile than men and with an ability to juggle a number of different priorities at the same time. Women can bring a different viewpoint and deliver different insights and perspectives to certain situations and these abilities act as enablers for women within their career. Women who enter into STEM want to challenge the social norms and as Interviewee J described they want to '*break the glass ceiling'*.

'*We do know that great leadership does not have a gender but the way we interact with people can deliver different results. As a women in my role in STEM I was not always given the same opportunities as men but I had a unique perspective that they didn't have and I used that to my advantage. And although it's not true across all males and females but in my experience I am able to see the untapped talent that women have, and if you help to develop women as leaders you will truly utilize the full potential of your organisation'*. (Interviewee J)

Competitiveness and a belief in equality

Some interviewees called out competitiveness as one of the enablers and a belief that '*girls were just as capable as boys in every subject'* (Interviewee Q).

Interviewee A remembered how a passing comment from a relative about her ability as a girl compared to a male cousin was what pushed her to excel in STEM subjects in school. '*We were both doing the same subjects and a comment was made that I would never do as well as my male cousin in the more difficult subjects like honour maths, that was all I needed to ensure I got the best marks I could and came out with higher scores. I am a competitive person, and it is something that has enabled me to push myself to achieve even more that I myself thought possible'* (Interviewee A). This sub theme was mentioned by only a few of the participants at just 10% but we believe it is an important subtheme as we will discuss in the findings. The lack of self believe and self-confidence has been highlighted as a major barrier to women so the idea that competitiveness could work as an enabler is one that should be further investigated.

Leadership Style

Although leadership style has been identified as a barrier to women in STEM it is also viewed as an enabler. As discussed earlier in the paper women can find it difficult to identify as a leader due to the 'think manager think male' mindset, but the question asked in this research looked to identify what leadership styles and traits the interviewees believed helped and benefitted their careers and capability as a leader and manger. Interviewee F described how she saw leadership as '*instilling ethics and morals in the people that you manage. Being supportive and encouraging and identifying people strengths and their weaknesses and helping to grow and develop in both areas'*. (Interviewee F)

Phrases such as 'approachable', 'collaborative', 'inclusive and fair' were all used when describing the style of leadership that the participants believed helped them in their senior positions. Interviewee B stated that '*you don't need to be abrupt and dismissive of people in a bid to flex your seniority muscles, people respond so much better to a supportive, respectful approach where constructive criticism can be delivered in a positive way'*. Interviewee H responded to the question with 'You *have to be a good listener to be a good leader and look to encourage your team to work towards achieving the team goals and objectives'.* These findings are consistent with what has been found in a number of pervious research (Helgesen,1990; Claes,1999) which state that innate femininity gives women an advantage in leadership roles.

Empathy and emotional intelligence were identified as enabling characteristics for women in leadership and executive positions as highlighted in the literature review.

Empathy helps leaders strengthen communication and connections with employees, as noted by Rosete and Ciarrochi (2005); these two factors, along with emotional intelligence, have been linked to transformative leadership (Rubini, 2017).

Empathetic leaders are able to perceive situations from the perspective of others, and emotional intelligence enables a person to recognize and manage the emotions of others. There were many examples of out interviewees using empathy and emotional intelligence to help in their careers and within their managerial and senior roles. '*Understanding your team and communicating effectively were areas I found really helped me in my career. Encouraging people and being respectful helped to allow you to call on other people if the need arose'* Interviewee C stated.

'*Allowing your team to be open about their struggles and ensuring you did not exploit this was very important. Being able to show you are trustworthy and just understanding when people are struggling helps to connect at a deeper level and allows you to be a better leader'* (Interviewee G)

The above section provided quotes from the interviews carried out with the 20 participants in this study. The interviewees shared their lived experiences as females that hold senior roles with STEM industries. These experiences shared by the participants helped to provide the information necessary to identify themes and sub-themes. Mentors and role models act as enablers and play a significant role in assisting the majority of participants in advancing their careers. Work life balance is a very important part a healthy work environment and a workplace that supports women career advancement while also helping them to achieve that work life balance is a desirable and motivating place to work. Lack of access to STEM courses and a lack of awareness of career potential within STEM industries was highlighted as some of the major barriers to narrowing the gender gap in STEM. The answers and discussions from the one-to-one interviews helped produce 8 themes and 19 sub-themes that were then labelled as a barrier or an enabler to the advancement of women's careers within the STEM industries in Ireland.

Findings

The research looks to highlight the factors that served as the major barriers and enablers to the participants career advancement. This section will summarise the 3 significate findings from our study which will be discussed in further detail in the discussion section. The researcher is drawing attention to three main findings in this section but will look to review an equal number of enablers and barriers in the discussion section.

Finding 1

The importance of mentors and role models as an enabler.

All of the participants in this study had multiple mentors during the course of their careers, with 80% still having a mentor. All of the interviewees emphasized the importance of a mentor in the growth of their professions, as well as someone they

turned to for guidance and support, and who helped to combat gender stereotypes within STEM. This is consistent with previous studies conducted by Stout et al (2011) The interviewees distinguished between formal and spontaneous or informal mentors, with the majority of participants claiming that their informal mentorship relationships were more advantageous since they felt more natural and organic, as opposed to artificial. In general, these results mirrored those of Cotton and Ragins (1999), Singh et al. (2002), and Bynum (2015).

Finding 2
Work life balance and motherhood as a major barrier to women's career progression.

In accordance with earlier findings, this study identifies parenting and motherhood as one that has a significant impact on women's careers. These studies have shown that women with children are more likely to work part-time or reduced hours, and that those who do so are less likely to be promoted or have a 'negative shadow' cast on their careers as identified by Waldfogel (2007). This study's findings validated the unconscious bias that mothers encounter in STEM industries and found clear support for earlier research that found that women devoted more time to family activities than men, whereas both sexes devoted the same amount of time to their jobs (Eby et al., 2005; Friedman and Greenhaus, 2000). Women take on the majority of home and child-rearing tasks, and the pressure of the 'invisible burden' and the 'second shift' is a major factor in women reducing their work hours and consequently being penalized financially. Overall, these findings are in accordance with findings reported by Gatrell (2004) and Hochschild and Machung (1989). Despite the fact that both men and women experience the second shift, women shoulder a disproportionate share of the burden, as noted by Gatrell (2004), who reported that women shoulder a greater share of family and domestic responsibilities, and Arlie Hochschild and Machung's (1989) classification of the 'second shift' as the household and childcare duties that follow after a person's paid job is completed.

Finding 3

Lack of exposure to STEM subjects in primary and secondary school impacts students' interest in pursuing STEM careers (Barrier)

The lack of STEM subject choices for Irish girls in schools is still a major barrier to a future career in STEM. This along with a lack of understanding of what is meant by STEM and the career opportunities within STEM are all worrying factors that are causing the gender gap in STEM. Research carried out as recently as February 2022 by the consultancy firm Accenture highlighted that only 59% of Irish people understand what is meant by the term STEM subjects. Worrying results from research carried out by McCoy et al (2012) and Delahunty et al.,(2021) in relation to lack of priority of STEM and the effect of self-selection bias by teachers can give some insight as to the lack of understanding and why survey results from I Wish (IWish, 2021) highlighted that 78% of the girls who participated in their survey viewed the lack of subject choice as a gender-specific obstacle to a career in STEM.

All of the women who took part in this study mentioned that this was a barrier for their careers in STEM, and they all agreed that it was concerning that this was still an issue for young women in Ireland's educational system.

Discussion

This study focuses on the lived experiences of female leaders or women in senior roles in STEM industries in Ireland. The purpose of this qualitative phenomenological study was to explore the blockers and obstacles that the participants have experienced from childhood through to their current senior roles and the what helped and supported their career progression. There is an underrepresentation of women in STEM fields and particularly in senior roles and despite the abundance of research carried out that emphasizes the value of diversity and equity within classrooms, college and the workplace, improvement in this area is very slow. A number of global programs and proposals have been designed and implemented (Karahan et al., 2015, Bilimoria and Singer, 2019) but progress is slow. It was shown in the literature review the proposed changes are being developed for the Irish curriculum and additional forms of teaching from primary to university have been introduced across the EU (Togou et al, 2018).

Policies and practices have been introduced in workplaces to help improve diversity, work life balance and job accessibility but still women are underrepresented in this area. This study looks to build on the research previously carried out on this topic globally and to highlight the obstacles faced by our participants within Ireland and discuss how they overcame these and to explore the enablers and motivators. The research looks to highlight the factors that served as the major barriers and enablers to the participants career advancement. The researcher will look to discuss the top two enablers and the top two barriers identified from the discussions and the interpretation of the participants lived experiences. Figure 1 depicts a summary of the findings gathered from our participants and reflective of the barriers and enablers they highlighted. Some of the findings in this study were in line and supported the conclusions of the literature review. In addition, there were new information and points of interest identified that would need further research.

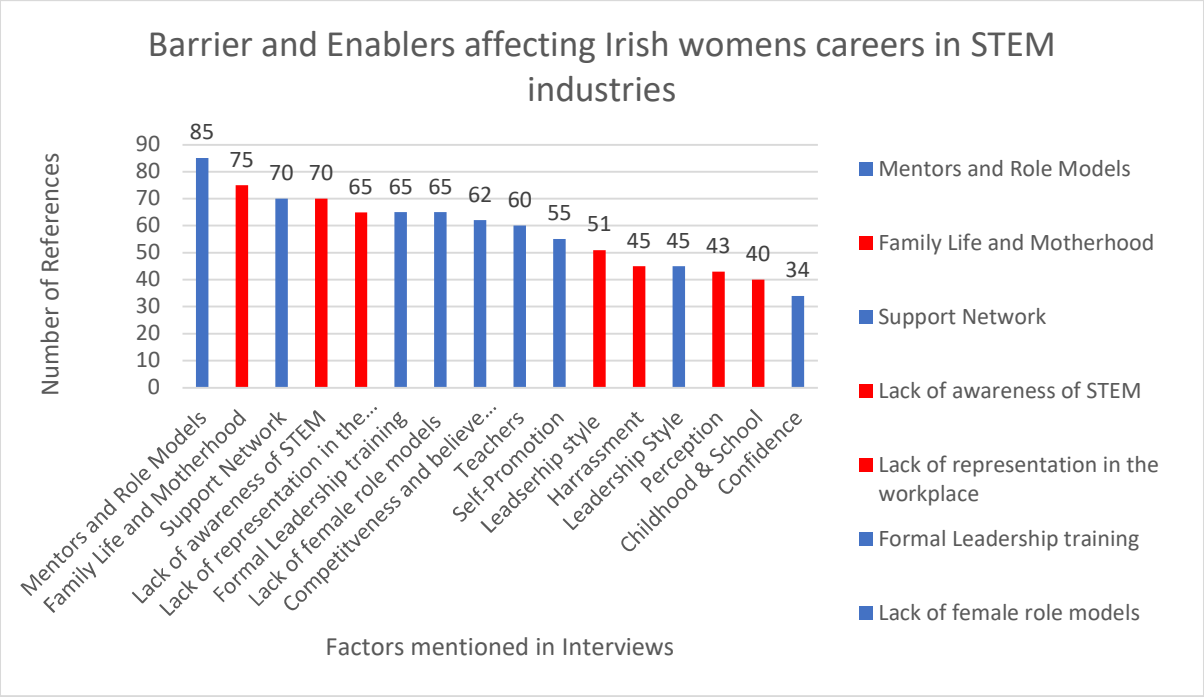

Figure 1 - Barrier and Enablers affecting Irish women's careers in STEM industries

Mentors and Role Models – Enabler

As reflected in the findings the importance of mentors and role models was highlighted as one of the primary enablers to the participants of this study through their STEM

career paths. 80% of the women we interviewed currently had a mentor that they looked to seek out themselves, 100% had mentors at some stage throughout their career but admitted that they were all less likely to have had a mentor early in their careers and highlighted this as an important factor for young females entering into the industry. 100% of the participants agreed they have been or currently are mentors themselves based on how important mentoring is for women. The advantages of effective mentoring reach well beyond the mentor and mentee themselves with participants agreeing that they too gained from being a mentor and from being a mentee. Our research corelates with previous studies and found clear support on how mentoring aides' retention and expertise within an organisation and helped to support self-confidence and work engagement (Benson et al., 2002; Dutta et al., 2011; Varkey et al., 2012).

Our research revealed the significance of mentorship to our participants, and as highlighted in the literature review previous studies have shown that women place a higher value on mentorship than males but are less likely to have mentors in early in their careers than men, despite the fact that they gain significantly more from mentoring in terms of professional development (Cross et al., 2019). This was also reflected in the data collected for this report. The question that then naturally arises is why women are less likely to enter a mentoring relationship early on in their career when research has shown the benefits mentorship bring and that women place a higher value on mentorship. The introduction of mentorship programs in primary schools and secondary schools to help support students should continue to be rolled out across all schools in Ireland, ensuring that these are also included in the DAS schools.

Family life and Motherhood – Barrier

In contrast to the enabler of a supportive family is the obstacle that is motherhood and work-life balance. Numerous research and studies have highlighted that within the family unit demands are not shared equally and women still continue to be the primary person responsible for household tasks and caring for children regardless of the work they do outside of the home (Hochschild, 1989; Baxter et al., 2008; Bianchi & Wang, 2012). Consistent with previous research, motherhood and work life balance were challenges faced by the participants in this study. The data gathered from our interviews found that women felt under pressure as '*you feel your biological clock*

overlaps with the timeline for career advancement' as stated by one interviewee. A number of our interviewees mentioned delaying career goals in order to have children, which is reflective of data gathered from a number of studies. One being that carried out by Herman and Lewis (2012) who evaluated the absence of suitable professional advancement for mothers who worked less hours to manage career and motherhood and proposed solutions to mend the "leaky pipeline". This is highlighted as a motherhood barrier over a gender barrier and is something that can be addressed with the support of employers and organisations. A more positive viewpoint on flexible working hours is what is needed to support mothers or fathers that are in motherhood or caring roles within a family.

Support Network – Enabler

Support network was commonly mentioned by the interviewees as one of the positive and encouraging factors in their advancement in STEM. As our society become more of a dual-earning society, the 'work-life-balance' friendly and family friendly employers become more attractive. the literature review shows that the majority of family and household responsibilities are carried out by women, who also work outside the home (Gatrell, 2004) and majority of women face into their 'second-shift' of housework and family responsibilities when they get home (Hochschild and Machung 1989). Our findings showed that through supportive family, partners and workplace our participants were able to continue their career into senior positions, but it was noted that not all women have these support systems, and their careers are what suffer. Professional Irish women want to have successful careers without it impacting on their private lives. Policies being put in place by the government in the form of the General Scheme of a Work Life Balance and Miscellaneous Provisions Bill 2022 are positive steps in a bid to support work-life balance. Working time flexibility is used in a number of different countries and companies to improve overall company performance and as a method of retaining staff.

Continued support of women in STEM is needed to help address the confidence gap as discussed in the literature review (Pomerantz et al., 2002; Madigan et al., 2007; Wolf, 2011). Young girls that show an interest in STEM need to be encourage but also women already in the STEM workforce need encouraged to progress into more senior

and leadership roles. Historically women have been portrayed as having a supporting role and not as the lead character. There is a shift in how women are being portrayed and the importance of gender diversity in leadership positions. Podcasts such as Women in Leadership (https://womeninleadership.ie/) and online platforms such as Women in Technology and Science Ireland (https://www.witsireland.com/) are all promoting a vision of equal opportunities for women in Ireland.

Lack of awareness and understanding of STEM – Barrier

This study found that in Ireland one of the major barriers women faced from a young age was the lack of exposure to STEM subjects in primary and secondary school. Children that had a parent in a STEM industry had an advantage over others and females felt dissuaded from pursuing a career in STEM, especially in Engineering and Mathematics. The influence of family was highlighted as an enabler when the family were supportive and had knowledge of STEM but was a barrier to many due to the lack of knowledge of the careers once you graduated college in the courses. Education, in schools and at home, on STEM subject and the career opportunities are crucial to the future of Ireland. Despite the fact the STEM Education Review Group was established as far back as 2013 with the aim of reviewing the STEM education in Ireland, and the development of Ireland STEM Education Policy to help promote and increase the uptake of STEM subjects in schools, girls' participation remains low (Delaney & Devereux, 2019). Lack of awareness and understanding of STEM and STEM careers was highlighted as a barrier to the participants of this study, whose careers started between 20 to 30 years ago in STEM. Unfortunately, this factor is still true for many teenager girls in Ireland today as discussed in the literature review where the results of the I Wish survey, was the largest survey of its type in Ireland in 2021, revealed that 78% of the girls who participated viewed the lack of subject choice as a gender-specific obstacle to a STEM career. The results demonstrates that although there has been a number of positive efforts made to increase female participation in STEM the root of the issue in Ireland seems to be the availability of STEM subjects in schools. Primary schools in Ireland do not have a specific STEM curriculum and as outlined in the previous research in the literature review teaching of science at primary level may be subject to self-selection bias based on the teacher's ability to teach the

subject (McCoy et al., 2012; Delahunty et al., 2021). STEM education programs continue to be in an out-of-school setting with different courses being offered by colleges such as DCU and privately run programs such as the courses offered by Steam-ed.ie.

According to research, the optimal age for pursuing STEM topics is between 9 and 13 years old; therefore, it is imperative that the government expedite the introduction of the new curriculum to ensure that STEM subjects are not only available to students, but that they are given the priority they deserve and that schools have the necessary resources and teaching methods to deliver these subjects effectively.

Further research

The researcher believes there are potential to broaden and expand this research basis of the findings. Future studies should investigate the potential benefits of unseen role models and mentors, particularly for young women. A role model need not be part of a mentor-mentee relationship; he or she is merely someone who can inspire and illustrate what is possible.

Future studies should investigate why so many female students in Ireland drop out of STEM programs. Retaining female graduates requires constant effort and attention; attracting female students is merely the initial step. Additional support networks and mentoring may be the solution to these problems.

Conclusion

This study aimed to evaluate and investigate the lived experiences of Irish women in senior positions in STEM industries in order to uncover the elements that have influenced their career advancement. The study was guided by previous research and by stages and identified factors that affect women's careers. The researcher carried out one to one virtual semi structured interviews with 20 participants and followed an interpretative phenomenological analysis approach for data collection. The participants described similar barriers and obstacles they encountered during their careers and similar enablers and areas of support. The researcher assigned themes

and subthemes to the data gathered. The analysis of the data led to 8 themes and 19 subthemes being discovered.

As past studies have demonstrated, having more women in leadership positions can lead to an increase in the number of women within an organization, and this study's participants viewed role models and mentors as a crucial enabler. Female role models need to be encouraged to stand out and be visible. Mentors and role models can play an important role in supporting newly graduated or prospective graduates to help map out their careers, but they also benefit the younger, school going generation. Mentors and role models in STEM help to reduce bias and help challenge stereotypes but societal change is only likely to happen when the predominately male majority accept that there is an issue and look to modify their attitudes and behaviour.

Career progression for women has been shown to be affected by motherhood. Research has shown that a working mothers' responsibilities and workload outside of their paying job has a significant impact on their career development. For organisations, career development of their staff is imperative for the company to thrive, so it is in the best interest of Irish companies to understand the pressures and put the necessary strategies and policies in place to ensure their employees career advancement is supported and they retain their employees. Family and work responsibilities are unavoidable and are one of the most common sources of stress for working adults. Work-life balance programmes need to be correctly introduced into organisations so that women can balance both professional life and family life without affecting their job security or promotion prospects.

Overall, this study contributes to the larger literature review on the factors that affect the advancement of women's careers in STEM in Ireland by shedding light on the main barriers and the major enablers. The types of support women have received within the STEM industry and in their leadership role are comparable and the data has shown that support through mentors, family, and work place is what is crucial to ensure women stay in STEM and have the opportunity to advance into leadership positions. The leaky pipeline of women in STEM is not caused by one specific factor and there is not one specific solution. Male dominated roles, gender stereotypes, and a view of a woman place in society are all factors that have added to the overall issue. Change takes time but we can see positive moves towards more gender equality and a higher

representation of women in senior roles in STEM in Ireland. Work must continue to change attitudes to women in STEM at every level. The government and schools need to ensure STEM is available to girls from primary school onwards and is given the priority needed along with showcasing to students and parents the career opportunities within STEM.

To move to more senior positions, women must be properly supported in an environment in which gender bias is eradicated and their abilities and achievements are recognized and rewarded. Organizations should attempt to promote more women to leadership positions in order to build a more diverse workforce and promote a shift in STEM-related attitudes. The lack of female leaders is not about the skills that women have or don't have, but it is more to do with the changing of mindsets and levelling the playing field. These measures will pave the way for a new generation of female leaders in STEM fields.

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Appendix A – Interview Questions

1. Can you describe your current role?
2. Was there a positive perception of STEM subjects for females in your school? Did the school offer any additional STEM programs? Or was there any encouragement outside of education that encouraged you to enter into the STEM programs
3. Did you study a STEM subject in college and if so what encouraged you to move into that area?
4. Did you engage in any additional formal or informal training to help you prepare or achieve the leadership role you are in?
    a. Would you recommend any to aspiring females that are looking to move into more senior roles?
5. Did you have a mentor at any stage in your career? Are you part of a mentorship program yourself?
6. What behaviours or qualities of leadership do you believe were enablers or barriers to you in your journey to your senior role?
7. What are your perceptions of gender diversity within your current organization or the organisations you have work in previously?
8. As a woman working in a STEM organization, have you seen or experienced any differences in the way you are treated compared to your male colleagues?
9. Can you highlight any specific enablers that helped you get to your leadership position?
10. What obstacles do you believe contribute to the under representation of women in leadership positions in STEM industry?
11. Is there anything else you would like to highlight or address about specific enablers or obstacles for women currently in the STEM industry or women considering entering into it?

Appendix B – List of Themes and Sub-Themes

Themes	Sub Themes	Theme Description	Number of respondents mentioning this theme one or more times (%)
Gender stereotypes & Bias	Perception and Unconscious Bias	Beliefs, attitudes, and assumptions made	43
	Childhood and School Experiences	Experiences of stereotyping as a child or in school	40
	Lack of awareness and understanding of STEM	Understanding of competencies and what is needed to develop interest in STEM	70
	Lack of Female Role Models	Lack of same sex role models had on gender-stereotypical ability.	65
Gendered Workplace	Harassment	Inappropriate behaviour, direct or indirect, verbal or physical, experienced in the workplace.	45
	Lack of representation in senior roles, mentors, and cheerleaders.	Effect of lack of female mentors and role models in senior roles within the workplace	65
Internal Barriers and expectations of women	Confidence	Effect self-confidence and self-defeating assumptions.	34
	Self-promotion	Negative views and misconception of self-promotion.	55
	Family Life, Motherhood, and the Invisible Load	The impact of family, cognitive household labour and gender expectations.	75
Leadership style - Barrier	Leadership style	The characteristics, traits and competencies of female leadership styles and how the affect their careers	51
Mentoring and Role Models	Teachers	The impact of teachers on students and career choices	60
	Role Models and Mentors	The impact role models and mentors have on careers	85
Support network	Family	the relationship between family support and career progression.	70 – these 3 areas were included as one
	Workplace	Benefits of a supportive workplace	
	On-line	Advantages and positive experiences from on-line communities.	
Formal leadership training	Formal leadership training	Benefits of a leadership and training programs	65
Ability, Determination and Passion	Interest	Motivation aspect of being interested in STEM	34 – these 3 area were included as one
	Capability	Understanding and capitating on capabilities	
	Competitiveness and a belief in equality	The role of completeness and a drive for equality	